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TRANSPLANTATION OF TOES FOR FINGERS

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LENINGRAD, U.S.S.R.

FROM THE CHAIR OF ORTHOPEDIC SURGERY AND TRAUMATOLOGY CHIEF SURGEON PROFESSOR R. R. WREDEN,
OF THE LENINGRAD STATE TRAUMATOLOGICAL INSTITUTE DIRECTOR F. I. MASHANSKY

THE attempts at restoring defects of the skin on fingers after the methods of Italian plastics (Nicoladoni, Coucher) have led Nicoladoni to develop the idea somewhat further. Taking into consideration the functional importance of the thumb, Nicoladoni,³ as early as 1891, made an attempt to compensate a considerable defect of the soft parts of the thumb by means of a corresponding flap grafted from the anterior wall of the thorax. The results obtained were fairly satisfactory.

The success of the case led him to further try the possibility of replacing lost parts of fingers or even the whole of an amputated finger. He intended inserting into the cutaneous rudiment of the thumb an osteoperiosteal graft, which had been slightly cracked with the view of giving it a bend. Unfortunately, he was prevented from applying the idea on a suitable case because another surgeon had performed an amputation. Following the same plan Nesske succeeded in two cases in restoring defects of the thumb with satisfactory cosmetic and functional results; the method has also been applied during the last few years by other surgeons and has been found to give satisfactory results. The operation is performed in two stages (Ritz) or sometimes even in one (Neigeisser). The former of the two surgeons, having split in half the fourth metacarpal bone, longitudinally sutured it together with the epiphysis into a cutaneous fold of the abdomen and then transplanted it on to the stump of the thumb; the results proved to be highly satisfactory. In 1898, Nicoladoni³ succeeded in obtaining even better results by utilizing the idea of an operation which had occurred to him a year previously, *i.e.*, by substituting part of the second toe on the corresponding side of the body for a partial defect of the thumb.

Eiselsberg¹ used the same method for replacing the distal half of the index. Likewise, Krause² (1906) substituted for both cosmetic and functional considerations the big toe for the thumb. Klemm performed the same operation with excellent functional results in replacing a thumb which had been cut off with an axe at the metacarpophalangeal articulation. In two years sensation was found to be completely restored. The above observations show the possibility of an autoplasmic substitution for part of a finger or even a whole finger, followed by its function being completely re-

stored. This is of particular importance in the case of the thumb and the index, but other fingers as well may be of great value, dependent on the patient's occupation. However, it should be borne in mind that patients submitting to the operation have to put up with a considerable amount of inconvenience in connection with a plaster-of-Paris bandage binding their

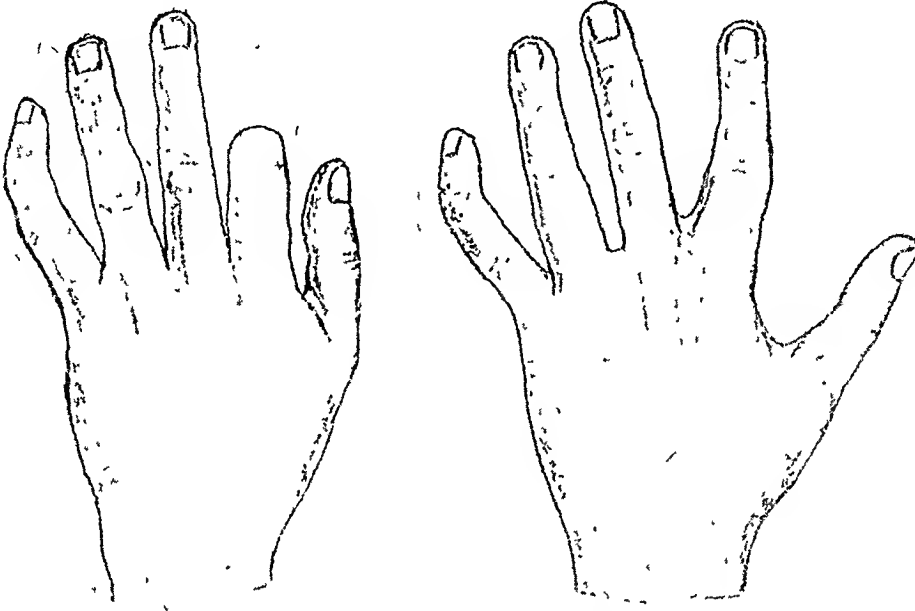


FIG. 1.—Showing site of amputation of left index finger.

FIG. 3.—Appearance of left index finger (toe) three years postoperative.

wrist and foot for a period of from two to three weeks, the body remaining during this period in a bent posture (Fig. 2). This is impossible in the case of stout people and is not endured by those suffering from hysteria. A primary grafting under conditions of a fresh trauma should be considered

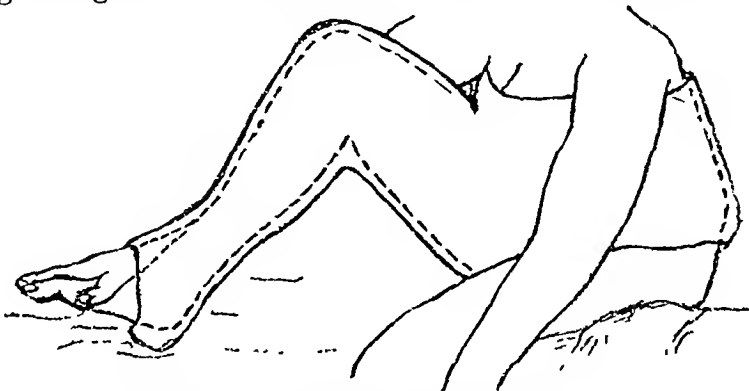


FIG. 2.—Showing position necessitated by application of plaster case, in order to maintain the apposition of wrist to foot.

decidedly inadvisable, for surgical interference within the region of recently injured tissues involves considerable danger and it appears to be hardly reasonable to sacrifice at this time a portion of an injured finger with the object of operating on sound tissues.

We perform the operation in two stages. The first stage consists in a small cutaneous flap being formed on the dorsal surface of the toe by means

of a transverse arched incision, the apex of the curve being directed posteriorly. The tendon of the extensor is sectioned if possible above the edge of the cutaneous flap. The phalanx is split transversely at the level of the base of the flap either by means of an osteotome or a Liston's forceps, or it is cut by means of a Gigli saw at a level which corresponds to the length of the defect. The distal end of the phalanx is then dislocated and the end of the thumb or finger stump is drawn up so as to come in touch with it, after a small dorsal flap of skin has also been formed on the stump and the tendon of the extensor has been exposed. The ends of the tendons are sutured together while a stable contact between the sectioned surfaces of the bones is ensured by means of suturing the surrounding soft tissues. The dressing material directly covering the wound may be fixed in place by strips of adhesive plaster and then a plaster-of-paris bandage joining the upper and



FIGS. 4 and 5.—Photographs of finger, showing excellence of cosmetic appearance and functional capacity.

lower extremities (the knee being bent) is applied. In 18 to 20 days the second stage of the operation is performed, which is analogous to the first stage, except for its being applied to the volar surface of the finger and toe and the tendons of the flexors and the incisions being sutured. In spite of a fairly long interval between the two operations, vascularization in the separated toe proves to be insufficient within the first week; the toe is cyanosed; cautious measures helping to keep it warm artificially should be administered to benefit its biologic processes. The first signs of restored sensibility appear only after several months have elapsed. Toes used for transplanting should always be taken from the same side of the body as the maimed finger. The highly irksome position in which the patients were obliged to remain for over a fortnight as a rule was borne fairly satisfactorily. In the case reported by Bier, Braun and Kümmel,⁴ it was necessary to cut

the bridge on the tenth day following the operation, as the patient was no longer able to stand this artificial symbiosis between hand and foot. Notwithstanding an aseptic postoperative course, this resulted in necrosis of the toe. Therefore, an interval of 18 to 20 days between the first and second stages of the operation may prove a failure unless the toe is duly taken care of after it has been finally separated.

In Soviet surgery we have so far had one case of a plastic operation with the object of substituting a toe for a lost finger.

CASE REPORT.—Patient V. A., aged 23, entered the clinic February 22, 1930. She complained of a defect of the left index finger which was the result of a trauma received seven months previously. A worker at the shoe factory "Skorokhod," the patient had had her left wrist caught in a press, and as a result of the accident her left index finger had been amputated (Fig. 1).

February 26, Professor Wreden, R. R., performed an operation after Nicoladoni's method with the object of transplanting the second toe (Fig. 2). The postoperative period took a normal course. Soon after the removal of the plaster-of-Paris bandage the transplanted toe began to show signs of restored sensibility to pain and temperature, while sensibility to touch was restored in three months.

At present, three years since the operation, the motor activity of the transplanted toe is normal (Figs. 3, 4 and 5). The patient is able to lace and unlace shoes, undo knots, *etc.*, with the aid of the left index finger. Hence, the results obtained are excellent both from a functional and a cosmetic point of view.

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POSTOPERATIVE PULMONARY ATELECTASIS

REPORT OF ELEVEN CASES

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POSTOPERATIVE pulmonary atelectasis has been the subject of much study in the past ten years. It has been recognized as of frequent occurrence and as the underlying factor in most pulmonary complications of surgery. The broader knowledge of the whole subject has made available means for reducing the incidence of the condition and for effectively combating it, once it has developed.

Postoperative pulmonary atelectasis may be defined as that condition existing when a part or all of one or several lobes of the lung becomes collapsed and airless after, or at the time of, a surgical operation.

Incidence.—In a very carefully studied group of 456 cases Brunn and Brill¹ found pulmonary atelectasis demonstrable by roentgen ray in 4.8 per cent. The incidence varies with the diligence with which it is sought and the diligence with which prophylactic measures are enforced. In our series the incidence in abdominal operations was 2.49 per cent in 1931, 1.77 per cent in 1932, and only 0.77 per cent in 1933. The average was 1.59 per cent. The incidence in all operations was 0.86 per cent (Table A).

TABLE A

Statistics on Postoperative Pulmonary Atelectasis

Year	All Operations	Cases of Pulmonary Atelectasis	Abdominal Operations	Cases of Pulmonary Atelectasis
1931.....	394	6 (1.52 per cent)	201	5 (2.49 per cent)
1932.....	347	3 (0.86 per cent)	169	3 (1.77 per cent)
1933.....	535	2 (0.37 per cent)	260	2 (0.77 per cent)
Totals.....	1,276	11 (0.86 per cent)	630	10 (1.59 per cent)

Etiology.—Most observers^{2, 3, 4, 5} now agree that the determining factor in the production of pulmonary atelectasis is bronchial obstruction by mucus. This factor was first recognized by William T. Gairdner,⁶ of Glasgow. He appreciated both the ball-valve obstruction and the complete blockage types. In 1912, Elliott and Dingley⁷ revived the mucous plug theory and were the first to emphasize its importance in postoperative atelectasis. Jackson and Lee,⁵ in 1925, reported relief in a postoperative case by aspiration of a plug of mucus through the bronchoscope. Since then Lee and co-workers^{8, 9, 10} have done much work on the subject. They have produced atelectasis in the

dog by obstructing a bronchus with the tenacious mucus obtained bronchoscopically from a patient suffering with postoperative pulmonary atelectasis. This was accomplished only after abolishing the cough reflex by sodium amytal given intraperitoneally. Some^{11, 12, 13, 14} have felt that bronchial obstruction by mucus does not explain every case of postoperative pulmonary atelectasis. Massive collapse of both lungs¹⁵ has occurred simultaneously with death of the patient, and the autopsy did not reveal any obstructive mucus. It has been suggested that some reflex stimulation of the vagus nerve might be responsible for the sudden collapse of a part or all of a lobe of the lung. It has been shown¹⁶ that muscle tissue extends into the finest of the bronchi and bronchioles, perhaps to the alveoli themselves. However, no one has been able to produce atelectasis experimentally by reflex stimulation.

There are many predisposing factors. In 1918, Allen O. Whipple¹⁷ made a very thorough study of postoperative pneumonitis. This was long before pulmonary atelectasis was generally recognized as the underlying factor in most pulmonary complications. Many of the 97 cases he reported would now be classified as pulmonary atelectasis. He discussed predisposing causes under the following headings: (A) Local inflammations in the upper respiratory tract and factors favoring them. (B) Vasomotor changes causing a congestion of the pulmonary vessels. (C) Factors inhibiting the normal thoracic and abdominal respiratory movements and favoring atelectasis and hypostasis in the lungs. (D) Local or general infections elsewhere than in the respiratory tract. (E) Debilitated states resulting in a lowered natural or acquired immunity to the particular organism inciting the pneumonia. (F) Factors increasing the virulence of the inciting organism. The first four of these groups cover most of the predisposing causes of pulmonary atelectasis as we view it today, and include important factors that have received little mention in recent reports. Subsequent work has elaborated, chiefly, the factors in group (C).

Churchill and McNeil¹⁸ have noted the reduction in vital capacity following operation. This is much more pronounced after operation on the upper abdomen, and during the first day after operation may be but one-third of the preoperative volume. Muller, Overholt, and Pendergrass¹⁹ have noted this, and also constant changes in roentgenographic findings following operation on the upper abdomen. Elevation and relative fixation of the diaphragm are always present. Transient, physical signs in the chest are frequently found. They have termed this condition pulmonary hypoventilation. Henderson²⁰ has attributed the changes to acapnia, a deficiency of carbon dioxide in the blood and tissues, arising from a disturbance of respiratory metabolism of the tissues, analogous to asphyxia.

Prinzmetal, Brill, and Leake²¹ have demonstrated an increased intrapleural pressure following surgery, which they have shown to be due to anesthesia, abdominal incision, traction on abdominal viscera, and pressure on the abdominal wall. This, unquestionably, acts in lowering the vital capacity of the lung, and thus favors the accumulation of secretion. Morphine, sodium

amytal, and other sedatives tend to decrease the amplitude and rate of the respiratory excursions and to dull or abolish the cough reflex. Spinal anesthesia is often accompanied by a slow, shallow respiration. The importance of a diminished, or absent, cough reflex should be emphasized. Anesthesia, preoperative and postoperative medication, acapnia, pain, and shock may all contribute. Van Allen and Lindskog²² have shown that cough loses its effectiveness as soon as the air has been absorbed from the obstructed lung. They have also shown that there are peripheral intercommunications between the branches of the bronchial tree, permitting the transfer of gases, fluids, and particulate matter. Hence, obstruction of any bronchus distal to the main lobe bronchus does not shut off all air to the part of the lung supplied by that bronchus, unless the intercommunicating channels are also blocked. This probably explains why pulmonary atelectasis does not occur more frequently.

It may be said, summarily, that all conditions which tend to reduce the vital capacity of the lung, or tend to increase the amount or viscosity of bronchial mucus, or hinder its expulsion, predispose to pulmonary atelectasis. Others would add factors predisposing to a reflex spasm of the bronchioles and bronchi.

Pathology.—The affected lung area is shrunken, airless, firm, gray in color, and sinks in water. The bronchi are often filled with a tenacious, densely adherent mucus. Microscopically, the alveolar walls are engorged with blood, and the alveolar spaces are flattened and small. They may contain an homogeneous mucoid substance and a variable amount of cellular exudate.

Symptoms and Signs.—In a typical case of severe, massive atelectasis the picture is that of a catastrophe. The onset is usually within 48 hours of operation, although it may occur long afterwards. There is usually a sudden elevation in temperature, pulse, and respiratory rate. The patient is usually dyspneic. He may be cyanosed. He may, or may not, attempt to cough. There is often severe pain in the chest or in the abdomen. The facies show anxiety. Expansion of the chest is limited or absent over the affected area. Often the interspaces appear retracted. Expansion on the opposite side may be increased. The apex beat of the heart may be seen to be displaced toward the lesion. In massive collapse of the right lung the heart may be entirely on the right side of the thoracic cage. Percussion will establish the position of the heart borders displaced to the side of the lesion. Early, there is often hyperresonance over the affected lung, but, as the bronchioles and alveoli become filled with secretion, dulness will be found. At first, the breath sounds are absent or diminished, and there are no râles. Later, as air again gains access, there may be tubular or amphoric breathing and moist crackling or bubbling râles. If the patient is turned on the unaffected side and carbon dioxide and oxygen are administered, he will usually begin to cough up a heavy, thick, tenacious, green sputum. The sputum is never bloody or rusty in color. In the course of a few minutes to many days the lung expands, the heart returns to normal position, and breath sounds can be heard over

the affected lung, with many moist râles. Dulness and coarse crackling râles may persist for many days after the lung reexpands.

By far the majority of cases of pulmonary atelectasis are less severe than the above. Most of them are not recognized unless the chest is thoroughly studied daily, or twice daily, following operation. Other cases will show slight temperature and pulse elevation, with or without cough. There may be little or no displacement of the heart, particularly where there is a small area of atelectasis in both lower lobes. The signs over the affected lung may be much the same as in the massive type, except that they are found only in small or scattered areas. Often the slight disturbance has been erroneously called a postoperative reaction.

Roentgenographic Findings.—In severe cases there are: elevation of the diaphragm on the affected side; narrowing of the chest on that side; increased obliquity of the ribs; narrowing of intercostal spaces; a displacement of the trachea, heart, and the mediastinum to the affected side; and a variable amount of shadow in the affected lung area. Early, there may be little or no increase in density over the lung; later, the shadow may be dense and homogeneous. Nearly all the papers on postoperative pulmonary atelectasis have reported extensive roentgenographic investigation of the cases reported. The roentgen ray, however, is not always essential in the diagnosis and treatment of this condition. Diagnosis can usually be made on the signs and symptoms and satisfactory treatment instituted. Where a portable roentgen ray unit is not available, it may be desirable not to use the roentgen ray. Due credit must be given the roentgenologists, whose good work has added so much to the knowledge of this subject.

Differential Diagnosis.—Dilatation of the stomach, ileus, peritonitis, pleuritis (with or without effusion), pneumonia, pulmonary embolism, cardiac failure, coronary thrombosis, and dextrocardia have all been erroneously diagnosed in pulmonary atelectasis. It is to be remembered that the first two may precede or may follow atelectasis. Pneumonia may follow, as may cardiac failure. Careful physical examination makes the diagnosis in the great majority of cases. Roentgen ray examination is of value in doubtful cases.

Following are brief reports of the cases of more or less severe postoperative atelectasis which we have recognized from 1931 to 1933.

CASE REPORTS

CASE I.—Mrs. A. L. F., aged 30, was admitted January 27, 1931. She had been in labor for twelve days. She had a mitral stenosis and insufficiency. Cesarean section was performed under spinal anesthesia. The first 24 hours after operation were uneventful and unusually comfortable. Thirty hours after operation she was given one-sixth grain of morphine by hypodermic. At this time the pulse was 120, while a short time before it had been 84. At 36 hours the temperature was 103°, the pulse 138, and the respirations 34. She was extremely dyspneic and cyanotic. Expansion was limited on the right, good on the left. The cardiac impulse was palpable to the right of the sternum, the apex beat just a little inside the left, midclavicular line. There were some dulness and absence of breath sounds in the right axilla. Oxygen, 90 per cent, and carbon dioxide, 10 per cent, were administered, and the patient was placed on the

left side. She showed some immediate improvement, but did not cough up anything. Seventy-two hours after operation it was noted that the respiratory rate was normal, there were a few coarse râles in the right axilla, and the heart had returned to a normal position; but the temperature and pulse rate were still elevated, and abdominal distention was increasing. The distention resisted all treatment, the heart dilated, and death occurred five days after operation. Permission for an autopsy was not obtained. It was our opinion that the collapse of the right lung was relieved, but that it initiated a cardiac failure, leading to death.

CASE II.—Mrs. H. B., aged 27, had a mitral stenosis and insufficiency. Sixteen hours after appendectomy, under spinal anesthesia, she began coughing, and developed pain in the chest, dyspnea, and cyanosis. Two hours later she coughed almost continuously for twelve minutes and expectorated a great deal of mucus. She was seen just after this and was still slightly cyanotic. The pulse was 130. The right border of the heart was three inches to the right of the sternum; the apex beat was just inside the left, midclavicular line. The breath sounds were obscured by coarse rhonchi and bubbling râles all over the chest. The patient said she had a great deal of mucus that she could not cough up. She was turned on the left side and given one one-hundredth grain of atropine sulphate. Temperature at this time was $100\frac{3}{5}^{\circ}$; the respirations 30. The patient was also started on tincture of digitalis by mouth. Thirty-six hours after operation the pulse had dropped to 108, respirations to 28; temperature $100\frac{4}{5}^{\circ}$, and the chest was clear of râles. The heart had returned to normal position, the right border being in the midline and the apex beat in the left axillary line. The temperature and pulse gradually fell, reaching normal five days after operation. This patient received three grains of sodium amytal and one-sixth grain of morphine sulphate three hours after operation. From then until the development of the atelectasis she was fairly comfortable and sleeping most of the time.

CASE III.—J. A., male, aged 21, had an appendectomy under spinal anesthesia. Thirty-four hours after operation he coughed up some green mucus. The temperature reached $103\frac{4}{5}^{\circ}$, pulse 140, respirations 44. There was some hyperresonance in the left axilla, and breath sounds were distant over the entire left lung. The heart and mediastinum were displaced to the left. When placed on the right side he coughed up more green, thick mucus. Twenty-four hours later he was very much improved; the temperature and pulse practically normal, and the heart almost back to normal in position. He was still coughing, and a few coarse crackles could be heard in the left axilla. The next day the chest was normal. This patient had one-sixth grain of morphine sulphate and three grains of sodium amytal just before operation and another one-sixth shortly thereafter. He slept most of the time following the operation, until the development of the atelectasis, although he had but one more dose of morphine.

CASE IV.—E. G. W., male, aged 37, had a repair of a traumatic hernia three hours after the injury. His convalescence was marked by an unusual amount of pain. Early in the morning of his sixth postoperative day the temperature reached $101\frac{2}{5}^{\circ}$; pulse 98. He had had a slight cough for 24 hours. The cough became more severe, and he expectorated some greenish mucus. There was some dulness in the left axilla, and there were a few crackling râles, but no appreciable displacement of the heart. He was turned on his right side. In two days the dulness had disappeared; there was still a slight cough; there were no râles. The slight cough persisted two more days. This patient received a grain of codeine a few hours before the development of the atelectasis.

CASE V.—T. M. K., male, aged 57, had an amputation through the right thigh for dry gangrene of the foot. For four weeks previous to the operation he had received huge doses of morphine for pain in the right leg and foot. He was given one-half grain of morphine sulphate before the operation, which was performed under a spinal anesthetic. In the first eight hours following operation he was given one and one-half grains of morphine sulphate to control severe spasms of pain in the right thigh and

lower abdomen. Eight hours after operation he developed an acute dilatation of the stomach. At the same time it was noted that the apex beat of the heart was lateral to the left anterior axillary line, and the right border of the heart was to the left of the sternum. There was hyperresonance in the left axilla, and no breath sounds were heard. Respirations 41; pulse 88; temperature $99\frac{4}{5}^{\circ}$. The stomach was evacuated and the patient turned a little on the right side. Carbon dioxide and oxygen had already been administered twice following operation and had been given the patient throughout the operation. Following development of the atelectasis they were given at frequent intervals, until the time of his death, which was 24 hours after operation. Pulse and temperature both continued to increase, the temperature reached 106° . He developed a generalized, pulmonary edema before death.

Postmortem Findings.—Thorax.—The heart was greatly displaced to the left, the apex being in the midaxillary line and the right border to the left of the sternum. Both pleural cavities were completely obliterated by old adhesions. The lower lobe of the left lung was about seven and one-half cc. in diameter and contained no air. The bronchus of this lobe was filled with a thick, tenacious secretion, which adhered firmly to the wall. There were no areas of consolidation in the right lung. The heart was enlarged and dilated. There was some organized blood clot in the left auricle, in addition to the postmortem clot. The mitral valve was greatly thickened, and the leaflets were somewhat distorted. The coronary vessels showed considerable thickening. The right femoral artery was filled with an organized clot up to the level of Poupart's ligament; a thrombus was present in the left popliteal artery. Gross pathologic diagnosis: embolus right femoral artery, left popliteal artery, amputation right leg above the knee, myocardial hypertrophy and dilatation, mitral insufficiency, coronary artery sclerosis, massive pulmonary collapse of left lower lobe, chronic pleural adhesions. Microscopic examination of the collapsed lobe of the lung revealed small, flattened, alveolar spaces filled with a homogeneous substance taking a pale eosin stain. A few leukocytes and erythrocytes were present in the alveoli. The alveolar walls were thickened, and the capillaries were distended with blood.

CASE VI.—W. T. C., female, aged 64, had a cholecystectomy and appendectomy under spinal anesthesia. Seventy-two hours after operation the pulse rose to 120 and the respirations to 50. There was slight abdominal distention; some cyanosis; limited expansion over the right lower chest; and some dullness in the right axilla, with distant tubular breath sounds and a few crackling râles. She was turned on the left side. Twenty-four hours later the temperature and pulse were practically normal, expansion of the chest was symmetrical, and there were no râles. She had a very prolonged and stormy convalescence. No further pulmonary complications developed until one month after operation, when after having been up three or four days, she developed fever and pain in the left lower chest. In 24 hours there was dullness all over the left base, with blowing breath sounds and many crackling râles. The temperature came down to normal in a week, with gradual clearing of the chest signs. This may have been an atelectasis, but was probably a pneumonia. This patient also had a chronic myocarditis and marked hypertension. Auricular fibrillation was present at intervals during her stay in the hospital.

CASE VII.—W. O. McD., female, aged 46, had a cholecystectomy and appendectomy under spinal anesthesia. She received one-fourth grain of morphine sulphate and three grains of sodium amytal before operation and frequent doses of morphine afterward. Within 12 hours after operation her temperature rose to 102° , pulse 106, and dyspnea developed. Twenty-four hours after operation dyspnea was still present, the heart was displaced a little to the right, and breath sounds in the right axilla were distant. Postural treatment was instituted and one-half ounce of whisky prescribed, t. i. d. Temperature gradually fell to normal over a period of five days. This patient had very little cough, but some expectoration of the characteristic mucus.

CASE VIII.—J. C., female, aged 12, had an appendectomy and drainage under

ether anesthesia. Preoperative medication consisted of morphine sulphate, one-eighth grain, atropine sulphate, one one-hundredth-fiftieth grain. Twenty hours after operation the temperature reached 105°, axillary; respirations 40, with some cyanosis. There seemed to be a great deal of mucus in the trachea. Expansion was greatly limited on the right. The right border of the heart was displaced one inch to the right of the sternum. Breath sounds were blowing, with loud, bubbling râles over the right, lower lobe. The patient was placed on her left side, and carbon dioxide and oxygen were given intermittently by nasal catheter. She was given whisky two drams every four hours. She immediately began expectorating a thick mucus, green in color. Each dose would stimulate cough and expectoration. Cough and expectoration continued for five days. At the end of this time temperature and pulse were normal and physical examination of the chest was negative. This patient received three small doses of morphine following operation and slept most of the time until atelectasis developed.

CASE IX.—Mrs. P. A. W., aged 25, had a cholecystectomy and appendectomy under spinal anesthesia, for acute cholecystitis and cholelithiasis. She received morphine before and after operation in liberal doses. Ten hours after operation the temperature was 103°, pulse 120, respirations 48. The respiratory excursion was very shallow, but there were no abnormal findings over the lungs, and the cardiac position was normal. Forty-eight hours after operation the heart was found displaced a little to the right, and breath sounds at the right base were distant. The respirations remained at 40 to 60 for 15 days after the operation. There was slight fever for 12 days, with a little elevation of pulse. During this time the patient coughed a little and expectorated a great deal of thick mucus. She did not feel or appear ill, except for the rapid respiratory rate. A roentgenogram 11 days after operation showed a high diaphragm on the right side, with a dense shadow in the right lower lobe. This patient was given carbon dioxide and oxygen during operation and at intervals of three hours for 48 hours after operation, then four times daily for another week. During this time her position was changed at frequent intervals.

CASE X.—Mr. E. R. D., aged 36, had a bilateral, inguinal hernia of such size that the scrotum hung at least ten inches below the inguinal ring and was ten inches in diameter. The right side alone was repaired at the first operation. Twenty-four hours after operation he was very uncomfortable and had mucus in his throat, but would not cough. Thirty hours after operation he became cyanotic, and the pulse was rapid and weak. The right side of the chest was almost immobile; the right border of the heart was in the right nipple line, and the left border in the left parasternal line. Breath sounds were absent over the entire right chest. He was given carbon dioxide and oxygen and turned on his left side. In the evening he started coughing up a thick, green sputum. Forty-eight hours after operation the pulse rate was down to approximately normal, the heart was back to normal position, and there were a few coarse crackling râles in the right axilla. He continued to cough up considerable sputum for another 48 hours.

CASE XI.—Mrs. J. S., aged 29, was admitted to the hospital December 23, 1932. She was coughing frequently, was slightly cyanotic and dyspneic, and the abdomen was distended to the size of a full-term pregnancy. Expansion was limited over the left lower chest. There was some dulness to percussion beneath the left scapula, with distant, harsh, blowing breath sounds and squeaking and crackling râles. The right lung was clear. The apex beat of the heart was well outside the left midclavicular line, and the right border was beneath the sternum. The patient complained of a cold in the head, cough, and pain in the left chest. The temperature was 100°, but fell to normal in 24 hours. The pulse rate remained about 100 throughout her stay in the hospital. The signs at the left base persisted. The patient was dismissed after 48 hours. For the next two weeks she was up and about at home. Some cough and signs of partial collapse at the left base persisted. At 2 A.M., January 8, 1933, the patient was awakened by pain in the right lower abdomen and nausea, and was again

admitted to the hospital. At this time the heart was still displaced to the left. At the left base, posteriorly, there was dulness, with distant tubular breath sounds and loud coarse crackling râles. The right lung was clear. There were acute tenderness and some rigidity in the right iliac fossa. Cesarean section and appendectomy were performed under spinal anesthesia. Convalescence was marked by considerable abdominal pain, and the complaint of mucus in the throat, which could not be expectorated. Seventy-two hours after operation acute dilatation of the stomach developed. Accompanying this there were slight dulness at the left base, limited expansion, distant blowing breath sounds, and coarse crackling râles. The stomach was evacuated and the patient turned on the right side. In 48 hours the lungs were normal to physical examination.

Comment.—An analysis of these 11 cases is interesting. Four patients had heart disease, and in three of these a mitral lesion was present. Two patients in the group had syphilis. In nearly every case the patient was either unusually comfortable from medication given preoperatively, or he was suffering severe pain, for which large and frequent doses of morphine were given. In seven of the cases atelectasis developed within the first 36 hours. Case VIII, aged 12, was convalescing from a cold and had a slight cough at the time of the appendectomy.

There were three cases following appendectomy, three following cholecystectomy, two following cesarean section, two following herniorrhaphy, and one following amputation through the thigh. Spinal anesthesia was used in ten of the cases, ether in one. This apparently shows a much higher incidence after spinal anesthesia. However, in abdominal operations we have used spinal anesthesia five times as often as ether, and it has been our policy to urge spinal anesthesia upon patients whom we considered poor risks, while ether, in most instances, has been used only in those cases where no trouble was expected.

There were two deaths. Both of these patients had heart disease, and both a mitral lesion. It can be stated with reasonable assurance that Case I would not have died had she not developed a pulmonary atelectasis. How much pulmonary atelectasis contributed to the fatal outcome in Case V is debatable. Both cases died with a myocardial failure.

Six of these cases occurred in 1931, including the two deaths, three occurred in 1932, two in 1933. The last two, Cases X and XI, had conditions tending to elevate the diaphragm, one a pregnant uterus, the other an increased intra-abdominal tension from a reduction of a large hernia. In the first of these the collapse was present before operation.

Table A shows the reduction in incidence during the three years. This reduction coincided with the institution of prophylactic measures. Beginning with 1932 carbon dioxide, 10 per cent, and oxygen, 90 per cent, have been administered to many of the patients. This method was first suggested by Yandell Henderson^{20, 23} and since has been recommended by others as a prophylaxis against pulmonary atelectasis. We have used it routinely during all spinal anesthetics. Carbon dioxide, 10 per cent, and oxygen, 90 per cent, have been given postoperatively to most patients taking ether anesthesia.

They have been given at intervals after operation in those cases deemed most likely to develop atelectasis. A copious flow of the mixed gases has been administered through an open cone held close to the patient's face. In a personal communication Dr. Walter Estell Lee has suggested that the carbon dioxide and oxygen should be given through a closed mask, and be re-breathed into a bag. He states that 8 to 15 inhalations rebreathed into a closed rubber bag will make anybody cough following the hyperventilation induced.

Another important factor in this reduction in our cases revolves about preoperative and postoperative medication. For the past two years we have given three grains of sodium amytal the night before, but none the morning of operation. The size of the dose of morphine has been reduced.

Prophylaxis.—After a consideration of the literature and the above clinical data, the following program is suggested:

(1) Postoperative pulmonary atelectasis should be anticipated and every effort made to avoid its occurrence: in patients with inflammation of the respiratory tract, including that induced by ether anesthesia; in patients with heart disease; in debilitated patients; in very sick and drowsy patients; and in patients with factors promoting increased abdominal tension. It is to be remembered that local and spinal anesthesia, apparently, do not decrease the incidence of pulmonary atelectasis.

(2) Large doses of morphine and other sedatives before and after operation should be avoided.

(3) On the operating table, pressure on the patient's chest by instruments, assistants, *etc.*, should be avoided. Operating time should be as brief as possible.

(4) Carbon dioxide, 10 per cent, and oxygen should be administered at intervals during all spinal anesthesia to avoid acapnia with its tendency to nausea and decreased vital capacity.

(5) Carbon dioxide and oxygen should be administered for five minutes at the end of all local and general anesthesia.

(6) Carbon dioxide and oxygen should be administered for five minutes, three or four times daily, for at least 48 hours following all abdominal operations, and after other operations when there is any possibility of atelectasis taking place.

(7) The patient's position should be changed every three or four hours after operation.

(8) Deep breathing at frequent intervals should be encouraged.

(9) Dilatation of the stomach should be avoided by using the nasal tube at the first indication of gastric distention.

Treatment.—All 11 of our cases were treated by the postural method recommended by Sante in 1927.^{14, 21} This consists in rolling the patient back and forth on the uninvolved side. Percussion over the involved lung facilitates the expulsion of mucus. The patient should not be left in this position for long at a time, as atelectasis may then develop in the other lung.

Carbon dioxide and oxygen are used therapeutically as well as prophylac-

tically. They induce deeper breathing and probably a widening of the lumina of the bronchi and bronchioles. They should be employed only in conjunction with the postural method of treatment. If they are administered with the patient lying on the affected side, it may lead to firmer incarceration of the obstructing mucus.

Whisky, undiluted, will often stimulate cough and expectoration when posture and carbon dioxide fail.

Before the postural treatment was introduced by Sante, the only direct way of attacking atelectasis was by bronchoscopic aspiration of the obstructing mucus. The use of this method in a postoperative case, as previously mentioned, was first reported by Chevalier Jackson and Walter Estell Lee. Lee, and Jackson's associates, Clerf and Tucker, subsequently reported a number of cases successfully treated in this manner.^{25, 26, 8} When posture, carbon dioxide, and whisky do not produce the desired result, bronchoscopy is to be considered, if one skilled in the use of the bronchoscope is available.

CONCLUSIONS

A knowledge of factors predisposing to the development of postoperative pulmonary atelectasis is of great importance in its prevention.

A number of these factors have received little attention in recent reports.

The reduction in incidence of this complication in our cases in the past two years demonstrates the value of recognizing predisposing causes.

The roentgen ray is not always essential to diagnosis and treatment.

The plan outlined for prophylaxis should make postoperative pulmonary atelectasis a negligible factor in surgical morbidity and mortality.

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GANGLIONECTOMY FOR HYPERHIDROSIS

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THE secretion of sweat is under the control of the nervous system. It can be produced in the feet of animals by stimulating the peripheral end of the cut sciatic nerve even after occlusion of the aorta and amputation of the extremity. In man very little is definitely known of the nervous mechanism involved. The existence of cortical centers is indicated by the fact that profuse perspiration frequently occurs as a consequence of emotional states. The work of neuro-physiologists^{3, 4} indicates that the cortex and brain stem exert controlling influences on the sweat centers of the spinal cord in animals. There is evidence to show that this influence is predominately inhibitory.^{2, 3} The spinal centers for sweating are apparently scattered throughout the length of the cord, probably in the ventral horns of the gray matter. They are in close proximity to the somatic motor cells and to the spinal centers for vasoconstriction. From their cells of origin the fibers for sweating leave the cord with the anterior roots and pass along the white rami communicantes to the sympathetic ganglia. Fibers from the cells of these ganglia pass by way of the gray rami communicantes to the spinal nerves and finally to the sweat glands. The fibers for vasoconstriction parallel those for sweat. Both are widely distributed as components of the peripheral spinal nerves, and supply areas practically identical with the cutaneous sensory distribution. By freeing certain sympathetic ganglia of their connecting rami and by removing the trunk which bears these ganglia, total inhibition of sweating can be produced in certain areas of the body without fear of sensory or motor loss.

It is not the purpose of this paper to discuss the factors which influence the secretion of sweat. It is sufficient to point out that the amount of sweating varies greatly in normal individuals, and under many different conditions. It may be increased to such an extent that it is definitely abnormal. Profuse perspiration may be the source of much annoyance, embarrassment and mental anguish, especially if it emits an unpleasant odor. Even though only moderately increased in amount, the odor or color of perspiration may be offensive. Certain substances may be excreted in the sweat which spoil materials on which the individual works, thus interfering with his occupation, as for example, in bromidrosis the sweat affects metals. Abnormal sweating may be the main etiologic factor in certain skin diseases, which involve primarily the extremities. When conditions of sweating occur which interfere with the health, occupation and peace of mind, or the continued happy existence of an individual, and if conservative measures give no relief, surgery is indicated. Sympathetic ganglionectomy at the proper level will

produce a total inhibition of sweating in the desired regions (Fig. 1). Whenever anhidrosis is thus produced, there occurs vasomotor paralysis in the identical areas of distribution, as evidenced by rise of surface temperature. It is impossible to influence separately the fibers for sweating and those for vasoconstriction by surgical means; but this accompanying release of normal vasoconstriction gives no uncomfortable symptoms.

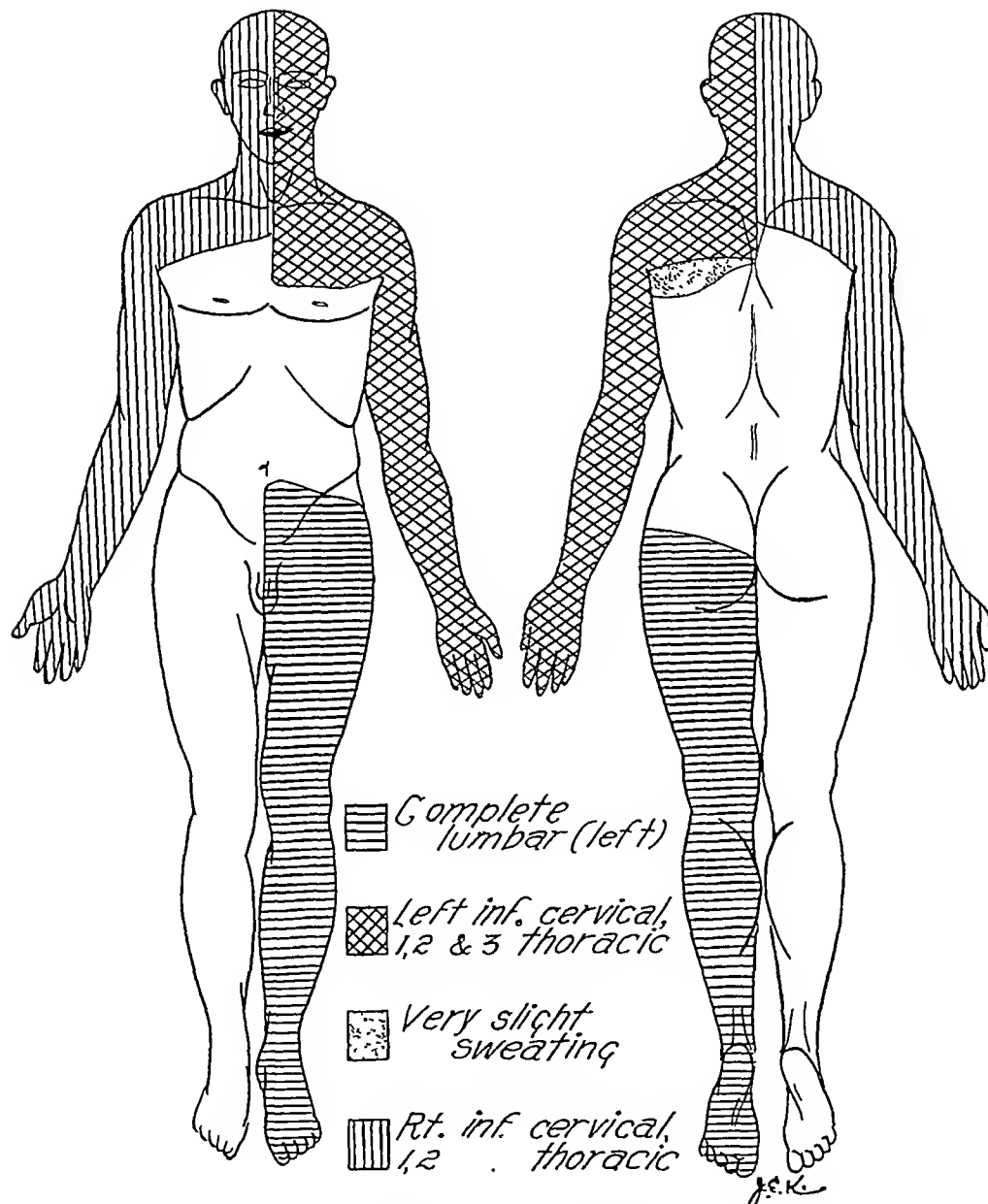


FIG. 1.—Areas of anhidrosis produced by sympathectomy. External heat was used to delineate the affected areas.

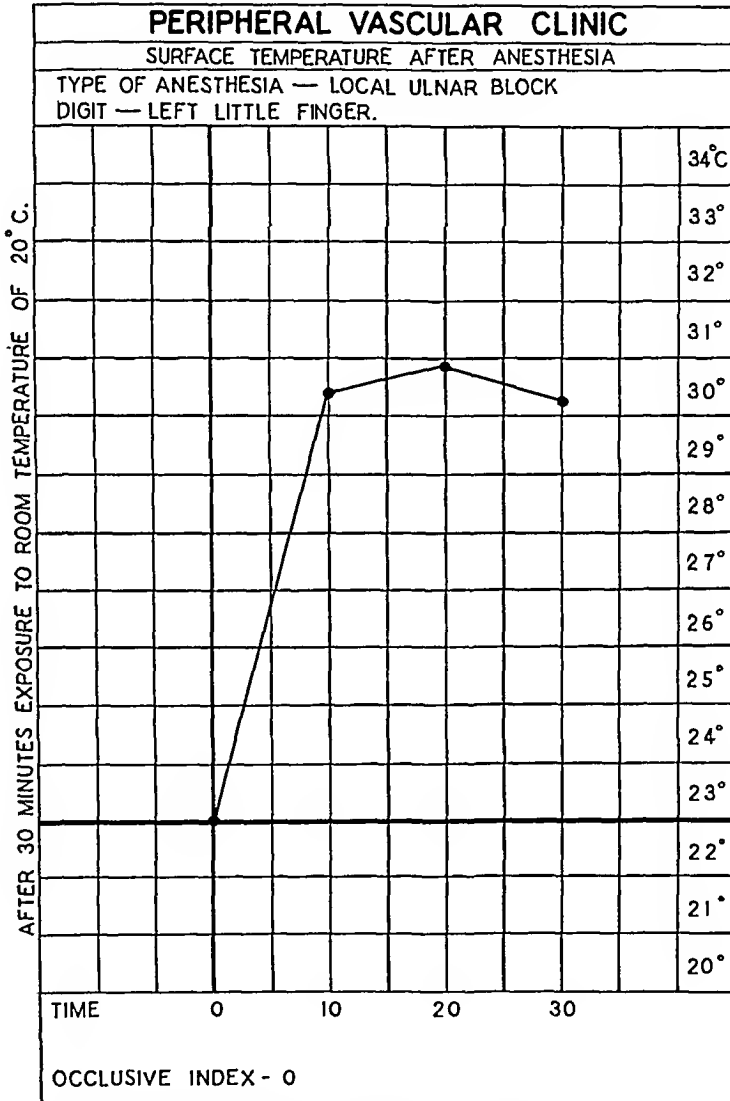
CASE REPORT

An unmarried Jewess, 22 years of age, presented herself at the Sympathetic and Vascular Clinic of Mount Zion Hospital November 28, 1933, complaining of marked perspiration of the hands and feet since she was eleven years old. Her hands were often cold and blue, especially in cool weather. The sweating was worse when she was nervous, or when she worked at her usual employment as a candy maker. In the past few years the perspiration had increased to such an extent that it interfered with her occupation. She constantly carried a handkerchief in her hand to absorb the excess sweat, and suffered

much embarrassment and mental anguish in her social life. Her feet were involved to a much less extent than her hands. There were never any attacks of local syncope.

On examination of the hands one noted that there was a moderate diffuse cyanosis of the digits, worse at the acra. There was a profuse sweating of both hands extending to the wrists, worse at the skin folds and on the palmar surfaces. Large drops of sweat fell from the outstretched hands. The sweat was clear, colorless and odorless. When the hands were immersed for ten minutes in water at 16° C., there was a marked blotchy

ABNORMAL SWEATING OF THE EXTREMITIES



Graph showing normal vasodilatation response to ulnar nerve block. The anesthetic area became dry, pink and warm.

cyanosis, worse at the finger tips, due to precapillary arteriospasm. All palpable arteries had normal pulsations. The feet presented a similar, but less marked picture. The sweating was present to the ankle. All arterial pulsations of the feet were normal. The clinical diagnosis was "sympathetic imbalance, vasoconstriction type, with abnormal hyperhidrosis." For three months she was treated with tissue extract subcutaneously, diathermy to the cervicodorsal spine, faradic stimulation, and nerve sedation with the hope of diminishing sympathetic activity without result.

On February 24, 1934, both hands were exposed for one-half hour to a constant temperature of 17.2° C. and skin temperatures measured with the Tycos thermocouple.

GANGLIONECTOMY FOR HYPERHIDROSIS

The left ulnar nerve was then blocked with novocain at the elbow. There was prompt anesthesia confined to the ulnar distribution, with total absence of sweating and prompt rise of surface temperature to the normal vasodilatation level (Graph). The anesthetized zone was bright pink with vasodilatation in contrast to the cyanotic appearance of the



FIGS. 2, 3, 4 and 5.—Results of left cervicothoracic ganglionectomy. Sweating was produced by the application of external heat. Fine charcoal was then blown on the face, upper thorax and hand, which adhered to the moist areas but not to the anhidrotic surfaces. The Horner complex is noticeable.

unanesthetized areas. This confirmed our clinical impression that we were not dealing with vascular occlusion, but purely with spasm.

In April, 1934, after five months of continuous conservative therapy had given no relief, the patient was advised that she could be relieved by sympathetic ganglionectomy

and trunk resection. She elected surgical treatment, and April 8, 1934, operation was performed by one of us (F. L. P.). The left inferior cervical, first, second and third thoracic sympathetic ganglia were exposed by a posterior muscle splitting approach, freed of all connecting rami, and the trunk removed from above the inferior cervical to below the third thoracic ganglion. There was an immediate rise of surface temperature of the left upper extremity, to the normal vasodilatation level, and a complete absence of sweating of the left upper extremity and the homolateral half of the head, face, and upper thorax, anteriorly and posteriorly (Figs. 2, 3, 4, and 5). The Horner complex was present. The rise of surface temperature and the absence of sweating persisted in the areas affected until the present time, fourteen months after operation. It was noted that the amount of perspiration of the unaffected regions was greater than before operation. The delineation of areas of anhidrosis was obtained by the applications of external heat. Pilocarpin acts by stimulating the nerve endings, and its use might give erroneous information.

August 3, 1931, through an approach similar to that used on the left side, cervico-dorsal ganglionectomy, ramisection, and trunk resection was carried out on the right side to the same extent as on the left. The result previously described for the left side became bilateral.

At the present time, fourteen months after the first operation, and ten months after the second operation, anhidrosis persists in the affected areas. The patient is well pleased and suffers no inconvenience from the complete loss of perspiration of the head, arms, and upper thorax. Complete vasodilatation has persisted, although the skin temperature is higher on the more recently operated side. Sweating below the area involved is definitely increased over the preoperative amount. This has been previously noted by us in four additional cervicodorsal sympathectomies performed for other conditions. In a case of hyperhidrosis reported by Adson¹ and treated by sympathectomy, a decrease of sweating was noted below the level of anhidrosis. We cannot account for this in view of our previous experience. One would naturally expect an increase in the per unit area of sweating in the unaffected zone.

It is too early to judge whether this artificial surgical anhidrosis is permanent. In cats it has been found by using an electrical skin resistance method that the absence of sweating after sympathectomy is not permanent, the glands resuming their normal activity after many months.⁴ In about 45 days, however, there was a great fall in skin resistance to one-seventh of the maximum. In the case here reported, there has been no perceptible evidence of sweating even after long exposure to external heat, fourteen months after operation. One hesitates to apply to humans conclusions based on animal experimentation; and again there may be other factors which alter skin resistance so that the latter may not be a true measure of the degree of sweating. Nothing but clinical examination in humans can give a definite idea as to the permanency of anhidrosis induced by sympathectomy.

SUMMARY

There are instances when sweating which is abnormal in amount, color, odor, or chemical composition calls for surgical interference.

Sympathetic ganglionectomy and trunk resection will produce complete absence of sweating in certain definite regions, depending upon the ganglia removed.

A case is reported in which complete relief from excessive sweating was obtained following sympathetic ganglionectomy and trunk resection.

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SPLANCHNIC NERVE SECTION IN JUVENILE DIABETES

II. TECHNIC AND POSTOPERATIVE MANAGEMENT

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IN A previous article,¹ it was stated that the severe type of juvenile diabetic with unstable tolerance, one that has been diabetic for at least two years and adequately controlled for several months before the proposed operation, and one that shows no detectable vascular damage by films of peripheral vessels and ophthalmoscopy, is the type in which an operative procedure to improve carbohydrate metabolism could be undertaken with any justification. The experimental work serving as a basis for this operation has been described elsewhere.^{2, 3} In addition, two tests were described for the selection of the proper case, the test for insulin-sensitivity and the test for ergotamine response after a galactose-hyperglycæmia.¹ The first test separates the insulin-sensitive from the insulin-resistant cases. As splanchnic-nerve section produces increased sensitivity to insulin,² only the insulin-resistant diabetic can derive any benefit from splanchnic-nerve section. The second test, briefly referred to as the galactose-ergot test, serves to indicate the effect of a sympathico-adrenal exclusion on carbohydrate metabolism. Should this test show a marked suppression of the galactose-hyperglycæmia by ergot, it augurs well as to the effect of splanchnic section. This was shown to be true by comparing such tests before and after operation. When the diabetic does not respond to ergot, a sympathetic depressant, nothing can be expected from splanchnic-nerve section.

When the juvenile or adolescent diabetic conforms to these requirements, one other point deserves serious consideration: Is there any evidence of tuberculous infection in the lungs or elsewhere? Tuberculosis in diabetics has recently received a thorough statistical investigation in a series of important articles by Howard Root.⁴ Because of insufficient attention to this complication, one patient afflicted with latent or arrested tuberculosis has been subjected to operation. And while no harm seemed to have occurred as a result of surgery, the evaluation of the obtained result must necessarily have suffered.

Pre-operative Management.—The patient is under the continuous supervision of a competent internist before and after the operation. The urine is free or practically free from sugar, there is absence of acetone bodies in the urine, and lastly the blood sugar is around 180 milligrams or less. The diet contains 120 or more Gm. of dextrose a day to insure adequate glycogen storage in the liver. It is advisable to keep the patient from eight to ten days in the hospital before the operation to insure complete diabetic control and also to train the nursing service for their important help in post-operative

management. This consists of the examination of at least three daily specimens of urine during the day for sugar and diacetic acid, as the post-operative administration of insulin will depend primarily on the urinary specimens. Any student-nurse can be delegated to this task. Experience has shown that if internes or the main laboratories of large hospitals run these specimens, they will not be reported in time. As the nurses give the insulin and give it according to the urinary findings, it is logical to entrust them with these tests. Several days before the operation they are made to obtain these specimens, run them and report them on a special sheet. I attribute to these seemingly minor details the fact that operations which exposed the posterior mediastinum or the retroperitoneal spaces have all healed by primary union in spite of the presence of severe diabetes. On the morning of the operation, the patient receives a small dose of dextrose, say 200 cubic centimetres of unsweetened orange juice, which is covered with ten units of insulin.

Premedication and Anæsthesia.—The night before the operation a mild barbituric sedative, such as three grains of sodium amytal, is given not earlier than 9 P.M. In the morning this dose is doubled one hour before operation. In larger children, this morning dose may well be six grains of sodium amytal; in smaller children the dose should not exceed three grains. One-half hour before operation, morphine, gr. 1/6 with atropine, gr. 1/150 is given subcutaneously.

While the operation could be performed entirely under local anæsthesia, the anxiety and apprehension of these patients do more harm than the small dose of gaseous anæsthetic. Besides, the vicinity of and possible injury to the pleura may necessitate positive pressure. We begin, then, with a light ethylene anæsthesia and perform a paravertebral block of the ninth, tenth, and eleventh dorsal segments, together with a copious infiltration of the skin, subcutaneous tissues and paravertebral muscles along the incision, to be described presently. The syringe is kept full during the operation, and the intercostal nerves, the thoracic sympathetic trunk, the splanchnic nerves and the pleura are injected when exposed, not only to minimize the amount of general anæsthetic, but to block important reflexes, which may originate from the posterior mediastinum and which can produce shock.

Technic of the Operation.—Resection of the splanchnic nerves, while a much-used experimental procedure, has not been performed often in man. Most of the work has been carried out on cadavers, and transpleural,⁵ supradiaphragmatic,⁶ inframediastinal,⁷ and infradiaphragmatic⁸ approaches have been worked out. Of these, after considerable study on the cadavers, the supradiaphragmatic approach of Pieri,⁶ which is nothing else but a typical posterior mediastinostomy, has been selected. After I had done four of these operations on man, the important anatomico-surgical study of Craig⁹ became known. He modified Pereira's infradiaphragmatic approach. This operation consists of a posterior approach to the retroperitoneal space just below the diaphragm, utilizing a longitudinal incision about six centimetres away from the spinous processes, and was successfully carried out by Craig eight times.

The transverse "intersegmental" incision of Härtel,¹⁰ however, gives in my experience a better exposure of the retroperitoneal space in the upper abdomen. Recently, the excision of the aorticorenal ganglion was performed without any difficulty by Härtel's approach. Up to date, however, all splanchnic-nerve sections for diabetes, six in number, were undertaken by the supradiaphragmatic approach, which will now be described in detail. With increasing experience, the operation necessarily underwent certain modifications.

The patient is in a semilateral position. A paravertebral incision is made, four fingers from the mid-line, starting at the level of the angle of the scapula and curving laterally over the tenth rib or tenth intercostal space for a distance of five to six centimetres (Fig. 1, insert A). This lateral curve, while not necessary, has facilitated the resection of longer segments of ribs. With the help of a kidney rest and elevation of the arm above the head, separation of the ribs is obtained. The incision transects the long muscles of the back and exposes the tenth and eleventh ribs, which are subperiosteally resected for a length of about six centimetres, approaching the mid-line as close as possible. In order to facilitate the approach to the lateral surface of the vertebræ, the intercostal vessels are doubly ligated and cut. The intercostal nerves may be preserved but can also be transected without any harm. The distal stump of the tenth nerve is transfixed with a fine suture of black silk and wrapped up in a moist gauze compress. The endothoracic fascia, which covers the pleura and constitutes a definite fibrous structure with strands of smooth muscle, is now carefully incised and dissected away from the pleura throughout the length of the incision. Now the pleura is entirely free and peels away very easily from the spinal column. Should it tear at this stage, it is immediately repaired with fine catgut under positive pressure. I encountered this complication only once, during the first operation, with no harmful consequences. After the pleura has been stripped away from the proximal stumps of the ribs, which by the way are the most frequent sources of a pleural injury, it is wise to remove the remaining proximal stump and some of the transverse process with a double action bone-biting forceps. The pleura is now gently stripped with the right index finger, until the thoracic sympathetic trunk appears, surrounded by more or less loose connective tissue and fat. It may strip away with the pleura, in which case it escapes detection under the retractor, but if the endothoracic fascia has been split, it will remain on the bodies of the vertebræ. Good lighting in the form of lighted retractors or a headlight and continuous suction of the accumulating blood should insure a dry, well-exposed field. The thoracic sympathetic trunk may be identified by the bulbous swelling of its ganglia. Dissecting the pleura farther forward, the major splanchnic nerve appears, showing multiple connections with the sympathetic chain. Quite at the bottom of the field, just above the diaphragm, originating from the lowest thoracic segments, the minor splanchnic nerve may be identified but a search for it is unnecessary, as the sympathetic trunk is widely excised and with it the origin of the lesser

splanchnic nerve. After flooding these structures with novocain, both thoracic chain and splanchnic nerve are excised, removing as long a segment as possible. In order to prevent regeneration of the major splanchnic nerve, which occurs very rapidly in the dog, the proximal stump of the nerve is implanted into the distal stump of the tenth intercostal nerve (Fig. 1, insert B). I am indebted for this idea of sidetracking the regeneration of the splanchnic nerve into a peripheral nerve to Dr. S. W. Ranson, Director of

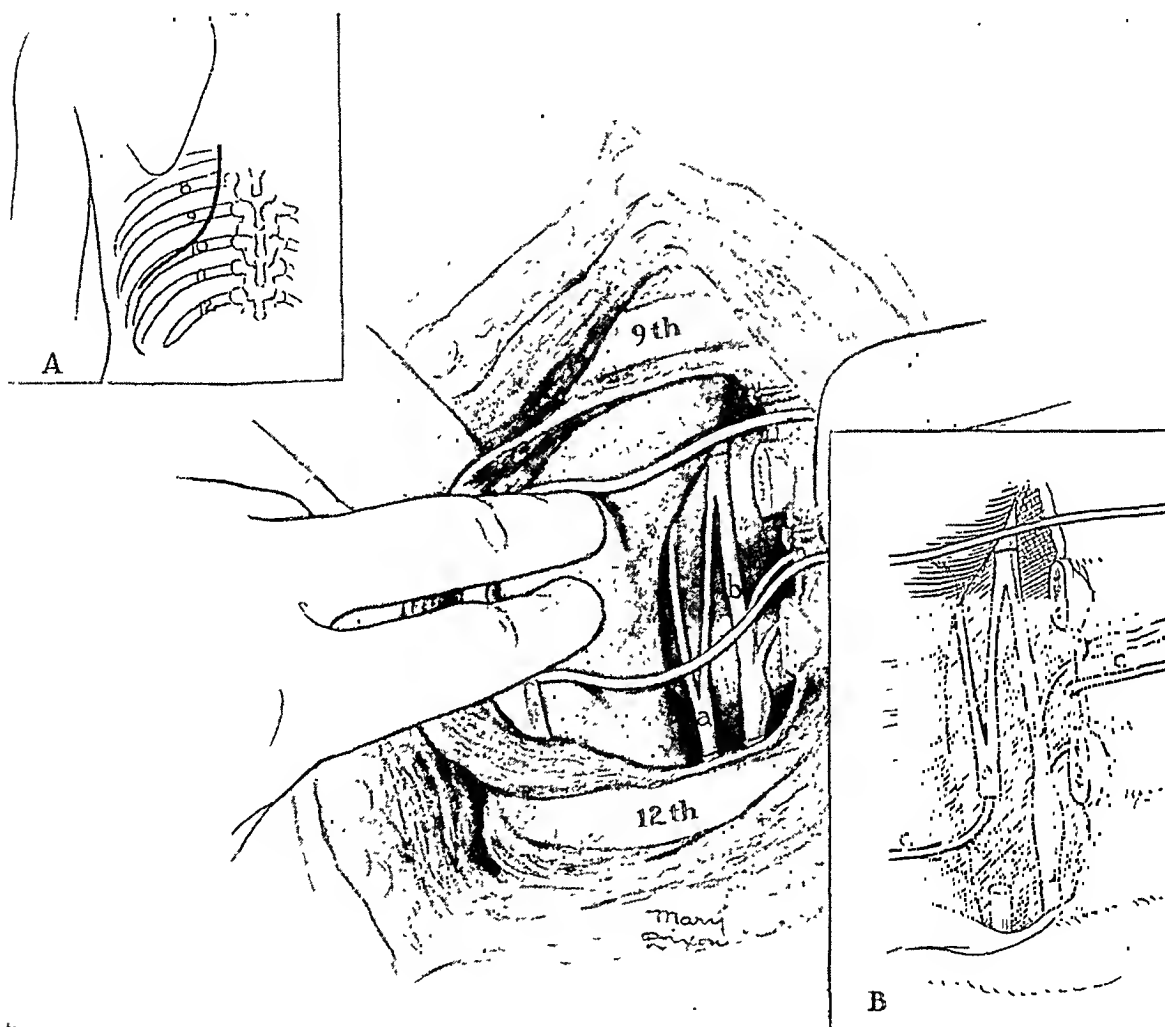


FIG. 1.—Insert A shows the line of incision, starting at the level of the scapular angle and swinging laterally at the level of the tenth rib. In the main drawing *a* is the major splanchnic nerve, *b* is the thoracic sympathetic trunk. The pleura has been reflected from the spinal column, the intercostal vessels have been ligated and only the intercostal nerves preserved. Insert B shows the method of anastomosing the proximal stump of the splanchnic nerve (*a*) to the distal stump of the tenth intercostal nerve (*c*).

the Institute of Neurology at Northwestern University Medical School. In the last two operations this procedure has been adopted, with no indication of any intercostal neuralgia or abnormal sympathetic reflex phenomena.

In regard to any possible vascular injury, care must be taken to avoid the intercostal veins entering the azygos and hemiazygos veins, respectively. These large collector veins are not in such close proximity to the splanchnic at this level, as they are below the diaphragm where their injury is much less readily avoided. After a complete hæmostasis, the pleura is allowed to fall back in its place, the muscles are carefully sutured with plain catgut

sutures and the skin closed, after meticulous adaptation of the skin edges with interrupted silk sutures. No drainage is left in the wound. The chest is adequately supported with wide adhesive tape.

Post-operative Management.—An adequate glucose and fluid intake, which is essential in any operation on diabetics, is carefully maintained. Five per cent dextrose solution is given in a subcutaneous drip, 1,000 cubic centimeters in about five hours, which can be started during the operation, and another 1,000 cubic centimetres in the afternoon. Two thousand cubic centimetres of 5 per cent dextrose solution will supply 100 Gm. of sugar. Another 1,000

cubic centimetres of Ringer's solution is given during the night, thus furnishing 3,000 cubic centimetres of fluids during twenty-four hours. While after laparotomies or retroperitoneal operations oral feeding may have to be delayed for two to three days, the thoracic approach permits an early administration of fluids by mouth. Thus, in all six instances the 100 Gm. of dextrose could be furnished by mouth the day following operation. The liquid diet consists of orange juice, milk, but better than that, sweetened tea. Orange juice in larger amounts frequently increases post-operative distention and is more irritating to the bowel than sweetened tea. Should the entire 100 Gm. be not consumed by mouth, another quart of 5 per cent, dextrose under the skin easily supplies half of it.

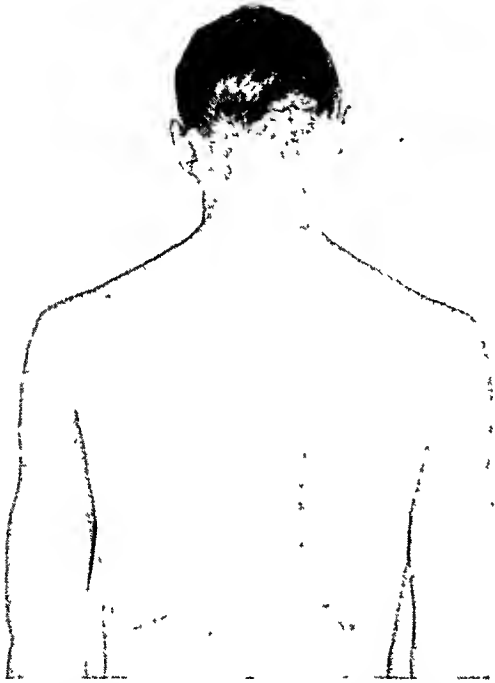


FIG. 2.—Photograph of patient's back a few weeks after the two-stage operation. This boy lifts heavy weights and works all day on a farm. The function of the back is unimpaired.

The patient must be considered a total diabetic right after the operation and the dextrose given must be completely covered by insulin. As mentioned above, the urine is examined every four hours for sugar and acetone bodies. A red reduction calls for twenty units, an orange reduction calls for fifteen units, a yellow reduction for ten, a green reduction for five, and no reduction for omission of insulin. All these patients require at least forty-five units of insulin right after the operation and probably more, but the insulin requirement suddenly drops after a few days when the post-operative reaction subsides. The urinary control protects from insulin reactions, but it is wise to have an ampule of 50 per cent dextrose at the bedside for any untoward event.

The patient is made to sit up the evening of the operation and breathing exercises are started the next day. Enough morphine is given to make deep

breathing possible. A mild enema of an ounce of glycerin and water each is given on the morning of the third day. After from ten to twelve days the patient is usually fit for an operation on the other side. The average stay in the hospital including ten days of pre-operative preparation was one month.

Results.—The surgical convalescence of three patients who underwent six operations was uneventful. The first patient developed a unilateral pneumothorax, which disappeared in a few days. The last patient had a subcutaneous exudate from a continuous chromic catgut suture, which promptly disappeared when the catgut suture was removed. There was no limitation of motion in the back; the third patient (Fig. 2) did heavy labor on a farm six months after the operation.

Preliminary reports^{11, 12} reporting the effect of splanchnic section on the diabetic state of the patient have already been made. Fenn and I will analyze the end-results of this operation, its effect on alimentary hyperglycemia and insulin sensitivity. In this paper, which is primarily concerned with the technical aspects of this procedure, I merely wish to summarize our experience with the three patients, to date.

CASE I, a nineteen-year-old colored girl who was resistant to insulin and whose galactose-hyperglycemia was readily diminished by ergot. In this case the insulin requirement dropped from forty to twenty units after the left side had been operated on. No further reduction was obtained after the second operation. She later became pregnant, broke her diet, aborted and lost some of her tolerance. From later surgical experience it may be stated with some assurance that the transection on the right side was incomplete and that adequate measures to prevent regeneration of the stump were not taken. She can be classed as a partial failure, mainly due to incomplete operation, aggravated by the complicating pregnancy and abortion.

CASE II, a sixteen-year-old white boy with a severe type of juvenile diabetes, showed no gain in tolerance, no change in the reaction to insulin and to galactose. This patient is a type of diabetic who showed no evidence of increased sympathetic impulses to the liver and could therefore not gain anything by the sympathetic denervation of liver and adrenals. It is only after this experience that the great importance of differentiating and excluding this type of diabetic from any surgical consideration was recognized. This case is classed as a complete failure, owing to the improper selection of the patient.*

CASE III, a twenty-four-year-old diabetic lad, had an arrested pulmonary tuberculosis, and recurrent hyperthyroidism which was checked by a subtotal thyroidectomy. Thyroidectomy reduced the insulin requirement from seventy to fifty-five units. Following bilateral splanchnic section, the insulin requirement dropped to ten units. Because the patient had gone back to work, the post-operative diet had to be increased with 700 calories, but no further increase in insulin was necessary. A reduction to five units was accomplished by small daily doses of ergot. This patient is very sensitive to insulin but needs a small amount, without which he spills large amounts of sugar. This case is undoubtedly the most successful to date, but the fact that he had X-ray evidence of pulmonary tuberculosis and a marked hyperthyroidism somewhat clouds the picture and interferes with the result. A final report will be made in detail at a later date.†

* This patient died during the first week of November, 1934, in a diabetic coma.

† After a strenuous summer on a farm, this patient showed a reactivation of his pulmonary tuberculosis. A large cavity appeared in one apex and the sputum became positive for Koch-bacillus. At the time of this note (Nov. 16, 1934) he is still maintaining the gain in tolerance.

Summarizing the results, the two important causes of failure, namely, inadequate technic and improper selection of the patient, have become obvious and may pave the way for more successful cases. These operations are admittedly experiments undertaken to remedy perverted physiologic-mechanisms. To evaluate the results, the first two cases must be excluded as faulty experiments.

Comment.—Of the many theoretical and practical considerations that arise from the proposal of sectioning splanchnic nerves in juvenile diabetes, the following questions are most pertinent:

(1) What is the effect of splanchnic-nerve section? In our animal experiments, to be published,³ it was found that this operation raises the sugar tolerance of the normal dog and markedly increases insulin sensitivity. The dogs store more glycogen in the liver, and this glycogen is more firmly fixed, because adrenalin does not readily mobilize it.¹³ It was also found that splanchnic section was equally effective in raising sugar tolerance as adrenal denervation.

(2) What is the advantage of splanchnic-nerve section over adrenal denervation? This question must be asked, as Crile has advocated adrenal denervation as a "dekineticizing" operation and has included diabetes among his indications.¹⁴ My reason for selecting splanchnic section instead of adrenal denervation is as follows: The splanchnic nerves control a far larger area than the suprarenal fibres; the abolition of central or reflectoric vasoconstrictor impulses to the extensive vascular supply of the islets may be of benefit. The deprivation of the liver of its sympathetic nerve supply definitely increases its storing and retaining capacity for glycogen.¹³ In regard to the adrenal glands, their denervation is practically as complete by splanchnic section as by adrenal denervation, although undoubtedly some fibres from the celiac plexus or lumbar sympathetic chain remain uncut. But regeneration after adrenal denervation occurs rapidly and a section of *all* nerve fibres to the adrenals remains, to say the least, a questionable possibility. The prevention of regeneration, as described in our operative procedure, can hardly be accomplished except by a supradiaphragmatic, retropleural approach.

It remains to be seen whether such a major surgical procedure is justifiable in a disease, the etiology of which is unknown and the transmission of which as a Mendelian recessive is being made more and more convincing.¹⁵ It is felt, however, that some of the obstacles in successfully attacking juvenile diabetes by splanchnic section have been cleared away by our initial experiences. Further observations on a larger material are being stimulated by the third case, in which a reduction from fifty-five to five units of insulin was accomplished, as a sudden but persistent result of the operation. No known surgical or medical procedure, including the total thyroidectomy as reported by Wilder and Pemberton¹⁶ has been capable of producing such a marked fall in insulin requirement.

Other possible effects of splanchnic-nerve section on gastro-intestinal motility, secretion and blood-pressure have been studied. There is no lasting

effect in influencing any of these normal mechanisms. This does not mean, however, that if abnormal mechanisms were present, they could not be influenced.⁹

SUMMARY

A supradiaphragmatic retropleural approach to the splanchnic nerves has been described. The operation has been performed so far in three juvenile diabetics. Because of improper case selection in one case and partial technical fault in the second, only the third case is regarded as a thorough test of the value of the operation. In this patient a decrease of fifty units of insulin a day was accomplished. A final evaluation of results with data on the diabetic state of the operated patients will be made.

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INFECTIVE GRANULOMA OF STOMACH

PSEUDOCANCER

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SURGEONS and pathologists of experience have encountered a condition of the gastro-intestinal tract that usually is erroneously diagnosed as neoplasm, most frequently cancer, which has proven inflammatory in nature on operation or postmortem examination. Notwithstanding the clinical importance of this condition, it has not been sufficiently stressed in the literature, and knowledge of it by the individual man is gained through disappointing experience.

Mock,¹ in one of the most complete reviews of the subject, named this lesion "infective granuloma," discussing at length the reasons for this name. From the clinical standpoint, however, it would attract greater attention if called by the name *Le Dentu* applied to it in 1909—"pseudocancer."² This name is especially appropriate in considering the lesion in its reference to the stomach. Whatever the etiology of these lesions may be, one fact is well established: they are not specific granulomata.

These inflammatory masses are met with not only in the gastro-intestinal tract, but, perhaps even more often, in the mesoblastic organs. Such a lesion occurring in bone has, on several occasions, been diagnosed as malignant and later reported as a cure from surgery. However, it is only when the lesion is situated in the stomach that the preoperative diagnosis is invariably wrong and only microscopic study reveals the true nature of the condition.

Because of their intrinsic benignity, these lesions are far advanced before surgical assistance is engaged; and because the prognosis, based upon the clinical examination and the roentgen ray, appears so grave the ultimate discovery that the lesion is benign is dramatic.

Two cases coming under my observation demonstrated to my satisfaction a few important clinical and pathologic points that deserve attention. In both cases, the preoperative diagnosis was carcinoma of the stomach, and surgery was advised merely as a palliation. Even at the time of the operation, I failed to distinguish the condition from a carcinoma, although I was struck by the extensive matting together of the stomach with the adjoining omentum and intestinal loops. The regional lymph nodes were enlarged and simulated carcinomatous involvement. At first, the histologic picture was baffling, but after repeated study the true inflammatory nature of the lesion was seen.

CASE REPORTS

CASE I.—A man, 54 years old, an American, a carpenter by trade, was complaining of postprandial pain for a number of years; when the pain would let up he felt quite

comfortable and had no distress whatsoever. Gradually the pain became a constant symptom. Two months before the admission to the hospital, he commenced vomiting undigested food and three weeks ago he could not retain water. He lost 52 pounds during the last six months, present weight 104 pounds. He was very pale and thin; his hemoglobin was 32 (Dare). A test meal revealed a total acidity of 18, free hydrochloric of 6, combined of 14 and blood. Roentgen rays showed an enormous filling defect (Fig. 1). The diagnosis of carcinoma of the stomach suggested itself, and, following a proper preparation of the patient, a wide resection of the stomach was done after Billroth II method, with a Pólya modification. Eighteen cm. of the stomach had to be removed so as to reach a safe margin beyond the lesion. The stomach was tightly adherent to the surrounding structures and the operation proved to be quite formidable. There was no vomiting following the operation. On the sixth postoperative day he showed evidence of peritonitis and he died two days later. Although no postmortem examination was done I feel that a leak from the duodenal stump was responsible for the peritonitis.



FIG. 1 (Case I).—Roentgen ray of stomach taken ten minutes after a barium meal. Showing the filling defect usually considered typical of carcinoma.

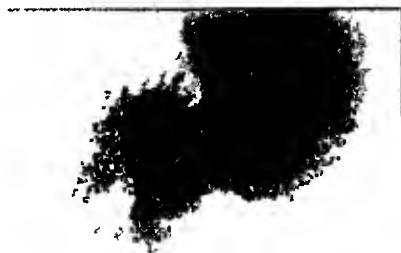


FIG. 2 (Case II).—Roentgen ray of stomach taken ten minutes after barium meal. Note the ragged-edged filling defect in the greater curvature near the pylorus.

CASE II.—A man, 43 years old, a Greek packing house employee, gave a history of upper abdominal distress related to meals for the last eight years. At first, the distress would come on in spells. Lately these became more frequent, and finally for two months before admission to the hospital he vomited undigested food repeatedly, and for the last week he even vomited water. A test meal disclosed a complete absence of free hydrochloric acid with a total acidity of 14, combined of 12, with a faint trace of lactic acid and two plus occult blood. Roentgen rays showed a definite filling defect (Fig. 2). The clinical diagnosis was carcinoma of the stomach, and a resection of the stomach was done May, 1931, after the Billroth II method. Because of dense adhesions of the stomach to the omentum, the duodenum and the pancreas, resection was tedious and difficult. During the first three months after operation he gained 28 pounds, resuming his usual occupation. The removed portion of the stomach measured 15 cm. in length; the resected part showed almost complete obstruction so that even a pencil could not be passed through the lumen.

The mucosa in the removed specimens of both cases appeared to be eroded in places. The specimens were extremely hard and leathery. The cut surface was white, glistening, with numerous yellowish spots; in places the cut edge felt cartilaginous. The lesion was not sharply circumscribed anywhere,

and faded out gradually into the normal stomach wall. Edema of the adjoining normal portion of the stomach made it difficult to be exact about the margin of the lesion. A close study of the advancing edge of the lesion sug-



FIG. 3.—Section from tumor in Case II. Showing the early stage of involvement of the stomach. Note the round cell focal infiltration of the submucosa.

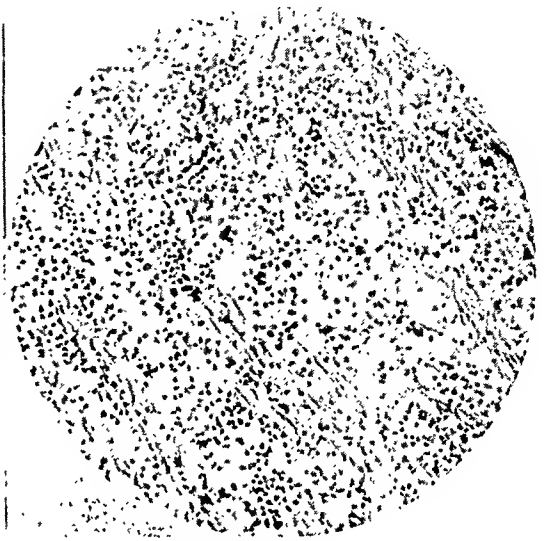


FIG. 4.—Section from same tumor as Fig. 3. Further stage of involvement of the wall of the stomach. The round cell infiltration is diffuse and organization has begun.

gests that a break in the mucosa precedes the inflammatory changes in the wall of the stomach.

Histologically, one may distinguish several stages in the development of

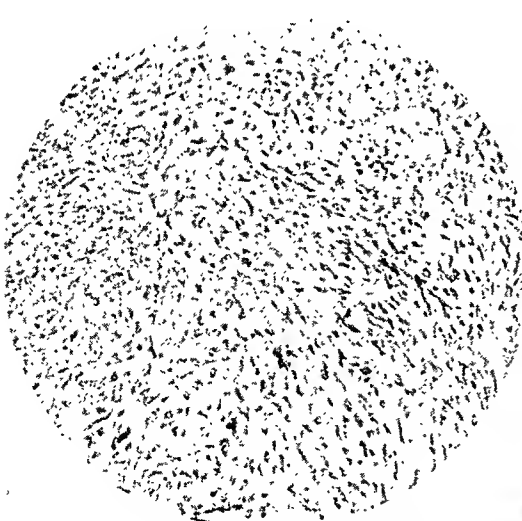


FIG. 5.—Section from same case as Fig. 3. The final stage of development of the tumor mass. Note the advanced organization of the resulting dense fibrous tissue.

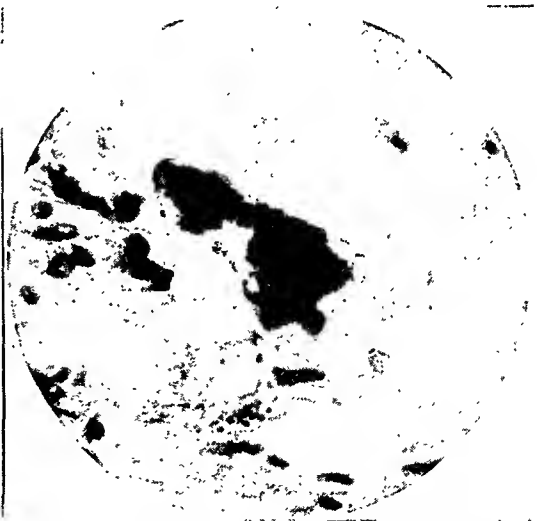


FIG. 6.—Section from same case as Fig. 3. Showing a large foreign body giant cell, as seen throughout the mature portion of the tumor mass.

the lesion. In the first stage (Fig. 3), we see an abundant, small cellular infiltration of the submucosa layer, which later leads to a diffuse infiltration of all the layers of the wall of the stomach (Fig. 4). An organization of this inflammatory exudate leads to the formation of a fibroblastic, dense, scar

tissue, that is responsible for the shrinkage of the wall of the stomach and for the narrowing of its lumen (Fig. 5). Dispersed among the numerous fibroblasts one sees foreign body giant cells (Fig. 6). When the inflammatory process reaches the serosa it causes a localized peritonitis that is responsible for the adhesion of the involved stomach to the adjoining organs. This peritoneal reaction is responsible for the postprandial pain.

Comment.—The diagnosis of gastric lesions by means of the barium meal and the roentgen ray is generally considered to be most reliable and trustworthy. My own embarrassment in the two cases presented here has taught me that one does well to be critical in the evaluation of the roentgen ray findings. This is said without any disrespect of roentgenology of the stomach, since even after the lesions are removed and studied in the pathologic laboratory, it takes a great deal of careful examination before the true diagnosis can be made.

Of course, it would be too much to expect that the clinician make the diagnosis of pseudocancer in these cases from the clinical examination alone. Looking back at these two cases, there are certain points which should have warned me against making the diagnosis of malignancy. The long duration of the illness with periods of complete freedom from symptoms, the absence of true cachexia in either of these patients, although a marked secondary anemia was present, and finally the postprandial pains which formed a prominent symptom in both of these cases, and which are seen in carcinoma of the stomach only after the tumor has reached the serosa, should have been given more consideration in the diagnosis than they actually received. And yet, when we are dealing with a middle aged man that has lost considerable weight because of repeated vomiting and who presents a palpable mass in the epigastrium, the suspicion of carcinoma of the stomach is great indeed. If in such a patient the roentgen ray shows a ragged edged filling defect and a delay in emptying time, one is naturally apt to accept these findings as evidence of malignancy. Despite this seemingly unimpeachable evidence of malignancy, the lesions here proved to be benign.

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FIBROSARCOMA OF THE STOMACH*

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SARCOMAS of the stomach are uncommon. According to D'Aunoy, Rigney and Zoeller,³ they comprise 1 per cent of all malignant growths in the stomach and 0.25 per cent of all sarcomas. Of the 135 cases of gastric sarcoma studied in detail by these authors, in only seven cases (5.2 per cent) were the growths fibrosarcomas. Gossage and Hicks,⁶ in 1913, were among the first to record the finding of this type of sarcoma at postmortem examination. Holmes,⁷ in 1919, described the successful resection of a similar tumor from the greater curvature. His patient, a man, was living and well six years later. Pember-ton,⁹ in 1929, added another case of successful resection of a pedunculated fibrosarcoma weighing 650 Gm. and measuring 20 cm. in its greatest diameter. D'Aunoy, Rigney and Zoeller were able to collect from the literature 335 cases of gastric sarcoma. Bell² stated that gastric fibrosarcomas seldom metastasize. Ewing⁵ was of the opinion that infection and congenital anomalies of the wall of the stomach might play important rôles in the causation of sarcoma.

In 1930, Balfour and McCann¹ stated that there were five fibrosarcomas in a group of 45 carefully studied sarcomas of the stomach which were collected at the Mayo Clinic between the years of 1908 to 1929. Resection of the tumor, with a Pólya type of anastomosis to restore gastro-intestinal continuity, gave the highest percentage of permanent cures (29.5 per cent). The symptoms commonly complained of were: dyspepsia, epigastric pain, fulness after meals, belching, and loss of strength. The usual physical findings were: epigastric tumor, an average loss in weight of 23 pounds (10.4 Kg.), occasional vomiting, melena, and moderate emaciation. Thirty-eight of Balfour and McCann's patients were treated by resection, and only 12 (31.5 per cent) were living at the time of their report. At the clinic, from 1908 to November 1, 1934, 4,733 carcinomas of the stomach have been treated surgically; in the same period 72 sarcomas of the stomach have been resected, of which seven have been fibrosarcomas. This is an incidence of approximately one gastric fibrosarcoma to ten gastric sarcomas (9.73 per cent).

Ransohoff and Dickson¹⁰ reported a case in which a gastric fibrosarcoma was successfully resected. They stated that these tumors are usually of a low grade of malignancy and commonly arise from the subserous layer of connective tissue in the stomach. They grow outward, attain great size, and are often pedunculated; rarely do they metastasize. At first glance they

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may appear to be inoperable because of their size and the adherence to them of the greater omentum and adjacent viscera. Such tumors usually arise from the greater curvature or from the posterior wall of the stomach in its middle third. Extensive resections are feasible with this type of sarcoma because of its sharp line of demarcation from the normal gastric wall. Deaudinsky⁴ mentioned a gastric fibrosarcoma that weighed 6,000 Gm. In one of Cabot's case reports there was recently recorded an instance of a small fibrosarcoma of the stomach of apparent neurogenic origin that was successfully treated surgically.

We wish to report a case in which a large fibrosarcoma of the stomach required very extensive resection in order to effect a cure:



FIG. 1.—Gross specimen of distal two-thirds of stomach, showing a pedunculated fibromyxosarcoma, which measured 11 by 11 by 10 cm. and which arose from the lesser curvature.

CASE REPORT

A farmer, aged 65 years, registered at the clinic October 25, 1934. His father had died at the age of 61 and his mother at 81 from what was said to have been cancer of the stomach. His past history was essentially negative. There had been no previous operations. His chief complaint was the presence of an enlarging mass in the epigastrium of one year's duration, and of progressive weakness. In the past 20 years he had had, after meals, occasional epigastric pain of about 30 minutes' duration. There had been no nocturnal pain, melena, nausea, vomiting, or hematemesis. One year prior to his admission to the clinic he had noted the appearance of a small, non-tender mass in the left epigastrium which had steadily increased in size. His strength had steadily diminished. Physical examination revealed a loss of 13 pounds (5.9 Kg.), which had occurred in the past two months; a moderate degree of pallor; a palpable mass in the left epigastrium, which measured 2.5 by 4 cm. and was freely movable, smooth, firm, and non-tender, and

enlarged, tender lymph nodes in the left axilla. The laboratory findings revealed the following: The urine was negative. Hemoglobin was 10 Gm. per 100 cc. of blood. Erythrocytes numbered 3,390,000 and leukocytes 6,000 per cmm. of blood. The flocculation test of the blood for syphilis gave negative results. Blood smears were negative. Roentgenograms of the stomach gave evidence of a perforated, ulcerating lesion on the lesser curvature in the middle third, probably malignant.

Operation.—October 27, 1934. First, two nodes were removed from the left axilla, these were reported inflammatory. Through an upper right rectus incision what was thought to be an ulcerating carcinoma of the lesser curvature was encountered; this mass was exogastric in character, filled the lesser peritoneal cavity, and apparently was inoperable. Further investigation showed that the tumor could be mobilized and that it did not involve neighboring viscera. Consequently, the first portion of the duodenum was divided, the stump inverted, and the distal three-fourths of the stomach resected, going well cephalad to the growth. A posterior Pólya type of anastomosis restored gastro-intestinal continuity. The pathologist reported that the lesion measured 11 by 11 by 10 cm. (Fig. 1), and that it was a pedunculated mass of mesentery and wall of the stomach; the tumor extended inward only to beneath the muscularis mucosa. Microscopic study of the tumor revealed it to be an hemorrhagic fibromyxosarcoma of Grade 2 or 3; parts of the tumor had the appearance of a neurofibroma.

The patient's postoperative course was uneventful, until the fourteenth day when bilateral bronchopneumonia developed. Oxygen therapy was used for the next five days. On the twenty-fourth day the temperature again became normal and the patient was dismissed from the hospital on the thirty-fourth day following operation. Postoperative roentgenograms of the stomach showed a free anastomosis and no signs of recurrence.

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ACUTE AXIAL TORSION OF THE UTERUS

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THE uterus in its normal state has little motility and is firmly held in place by the broad ligaments and the uterosacral ligaments. These widely distributed supports resist any tendency to torsion. But a large heavy fibroid of the subperitoneal type attached near the fundus of the uterus and well above the pelvic brim may rotate and exert traction on the uterus. It has inertia and a wide field of movement, and the more spherical its shape, the more easily it can rotate.

In 1909, Piquand and Lemeland¹ collected and reported 37 cases. Vautrin² added two the following year. By 1926, Hitzanidés^{3, 10} had brought the total number of cases to 86. In 1932, Pavlos,⁴ of Alexandria, added 15, bringing the total to 101. Thirty-two additional cases have been excluded because the torsion of the uterus was secondary to torsion of a fibroma with a pedicle and not due to the weight of the fibroma itself. With sessile fibromata the torsion of the uterus occurs at the same time as that of the fibroma.

These cases are of two types, acute and chronic. In the chronic cases there is a history of a long period of lower abdominal distress. In the acute cases there is sudden sharp pain which increases in intensity. In both types there is a round midline swelling having its origin in the pelvis and extending toward the level of the umbilicus. The point of torsion of the uterus is fixed, occurring as a rule at the level of the uterine isthmus. In three cases only the point of torsion was higher at the level of the insertion of the fallopian tubes.⁵ The elongation of the uterine isthmus may be so pronounced as to reduce the region just above the cervico-corporeal junction to a cord and cause venous obliteration and edematous infiltration. Persistent torsion has resulted in distention of the uterus by blood or pus, and widespread hemorrhagic infiltration in pelvic and subperitoneal tissues. Engorgement may spread to tubes and ovaries with the formation of peritoneal adhesions. With further rotation the arteries may become occluded causing necrosis of tissue.

Diagnosis.—The condition of axial torsion of the uterus is rarely diagnosed clinically, the abdominal tenderness and rigidity suggesting ovarian cyst with twisted pedicle. According to Gordon-Watson,⁶ two objections to this diagnosis are the solid consistency of the tumor and its apparent continuity with the cervix. Failure to pass a uterine sound may be of some diagnostic aid. In women still able to bear children cessation of the catamenia with acute abdominal pain and the presence of a smooth, solid, abdominal tumor continuous with the cervix point to axial torsion of the

uterus. Other symptoms may be present. In a puzzling case reported by Walker,⁷ there was diffuse pain down the front of both thighs, although none of the three upper lumbar nerves supplying the area affected enters the pelvis.

Etiology.—The etiology of axial torsion of the uterus is unknown. Causes given for ovarian cyst with twisted pedicle do not apply in these cases. Changes in volume of the bladder or rectum will not cause rotation. Vautrin⁸ suggests that peristaltic movements of the sigmoid may be the cause. Changes due to pregnancy play an important rôle, but the phenomenon is more common in nulliparae. Courty⁹ points out that in all the series only five women were under 40 years of age: in Schultz's cases the patients were 25 and 27 years of age, respectively; Freund's patient was 21; Loblein's, 25; and Wörtz's, 19. Rokitansky, Kocberle, and Lindig¹¹ favor Sellheim's theory that torsion of the uterus is concomitant with torsion of the body. In one case the woman was a reaper by occupation and the repeated spiral movement of reaping with the sickle was considered the cause of the torsion. Hitzanidés^{10, 12} believes that the weight, volume, and point of implantation of the tumor and the effect of gravity are sufficient factors to cause the torsion. The body of the uterus with a large myoma of ovoid shape may by the weight and traction of the fibroid be revolved on the isthmus and cervix.

Treatment.—Patients seek relief when the torsion causes severe abdominal pain. The extent of torsion varies between 200 and 360°, although Michalitz, Wertheim, and Homans¹³ report a uterus twisted one and one-half times upon its isthmus. The treatment in women past the child-bearing period or in cases where adhesions from an old pelvic inflammatory process are present is total or subtotal hysterectomy, preferably the latter, because it is simple, rapid, less hemorrhagic and more aseptic. Cases in which complications of salpingitis, oöphoritis, or peritonitis arise present a problem. Some surgeons have successfully postponed operation until the patient had recovered from the shock of the acute torsion. Courty,¹⁴ however, states that the best way to alleviate pain is to correct the torsion immediately. In cases in which the women may still bear children, enucleation of the myoma and detorsion of the uterus are indicated.

CASE REPORT (Case No. 30921).—L. B., aged 32, female, married, mill-operator, entered the Truesdale Hospital January 4, 1934, complaining of abdominal distress, gaseous distention, and eructations, which had persisted for two weeks. Two days prior to admission the pain in the lower abdomen became more severe, most intense in the midline and spreading to each lower quadrant. The attacks were of irregular onset and not related to the intake of food. The appetite remained unimpaired. There was no nausea and bowel movements were normal.

The menstrual history was normal. The last period, however, ended 35 days before admission. Two days before entry there was a scant show which became free-flowing on the day of admission. The patient had been married two years and had never been pregnant. The past and family history was negative.

Physical examination revealed a well-developed and well-nourished woman in mod-

TORSION OF THE UTERUS

erate abdominal distress. Temperature 99.8°, pulse 100 and respirations 20. The heart and lungs were normal. Blood pressure 120/70. A large, tender, slightly irregular mass could be felt in the right lower quadrant of the abdomen extending to the mid-line. Vaginal examination revealed a mass to the right of the uterus. The uterus was apparently of normal size.

The urine examination was negative. Erythrocytes, 4,530,000; leukocytes, 11,800; and hemoglobin, 90 per cent (Tallquist). The differential blood count and smear were normal. The non-protein nitrogen was 28.5 mg. and the blood sugar 111 mg. per 100 cc. The Kahn examination was negative.

A preliminary diagnosis of ovarian cyst with twisted pedicle was made. Ectopic pregnancy seemed less likely but was considered.

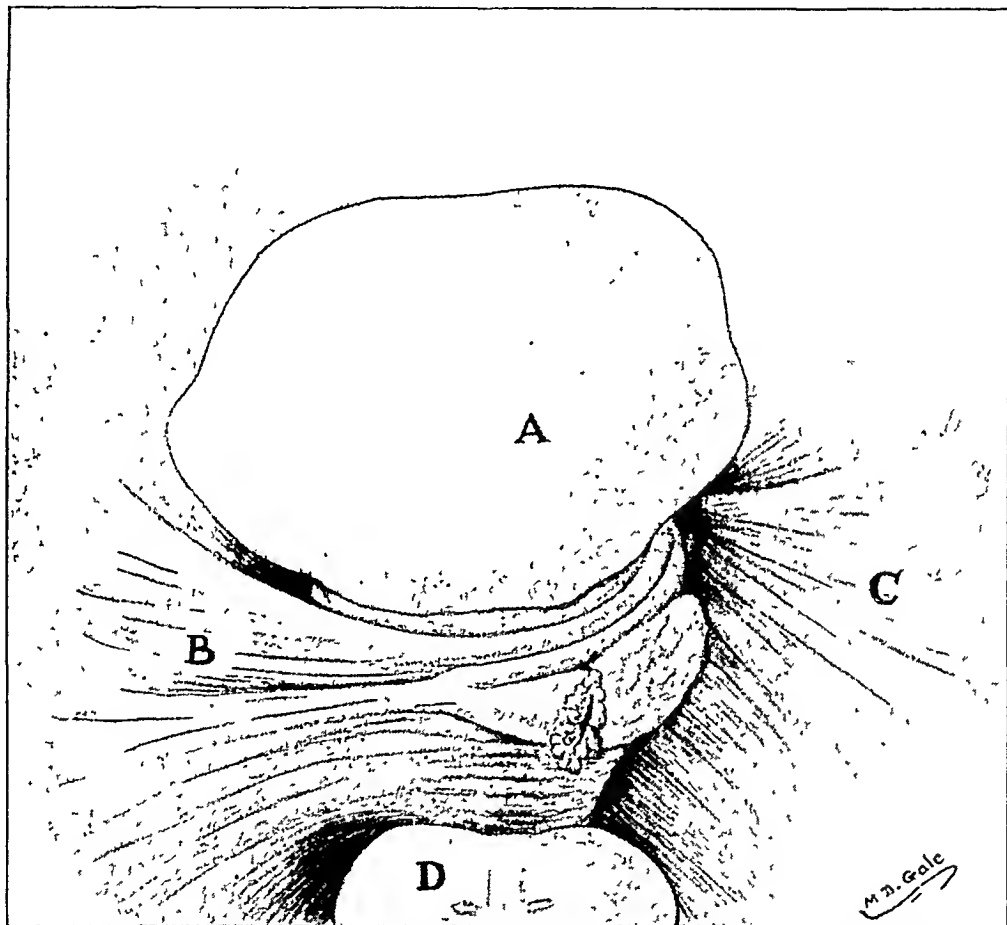


FIG. 1.—Posterior view of uterus. (A) Fibroid situated upon fundus of uterus. (B) Left broad ligament (wrapped around body of uterus). (C) Right broad ligament. (D) Rectum.

The following day under avertin anesthesia laparotomy was done through a lower midline incision. The peritoneal cavity contained a small amount of free blood. Exploration of the pelvis revealed an asymmetrical, nodular fibroid the size of a grapefruit situated upon the fundus of the uterus. The uterus itself was slightly larger and softer than normal and was twisted upon itself a complete turn of 360° at a point just above the internal os. The adnexa appeared normal. Except for its slightly congested appearance, the uterus seemed to show no serious interference in its blood supply. The torsion was easily corrected and with detorsion the color of the uterus rapidly changed to normal. Myomectomy was then done without opening the uterine cavity, and the musculature of the uterine fundus closed with two layers of catgut sutures. Incidental appendectomy was done and the abdomen closed in layers without drainage.

The patient made an excellent postoperative recovery. Convalescence, however, was somewhat prolonged by a right femoral phlebitis, which developed on the fourth postoperative day, and by a pulmonary infarction which occurred on the thirteenth postoperative day. These complications yielded satisfactorily to supportive treatment and the patient left the hospital recovered 30 days after admission.

Comment.—This case is typical of many reported in the literature. The uterus had undergone dextro-rotation through 360° , the torsion occurring in the region of the isthmus, which in this instance was not thinned out. In search for a site in the abdomen best suited to its shape, the myoma as it grew on the fundus rotated, pulling the uterus after it. The process of torsion was rapid after the fibroid had become large enough to exert traction on the uterus and cause symptoms of abdominal distress and pain. Torsion had not progressed to the extent of causing deep congestion or gangrenous changes in uterus or adnexa, although the uterus was somewhat congested. Myomectomy with detorsion sufficed to secure cessation of symptoms, and in view of the patient's youth more radical measures were not considered advisable.

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TORSION OF AN INTRA-ABDOMINAL TESTICLE

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TORSION is a frequent complication of undescended testis. Undescended testis or cryptorchidism in its various forms is quite a common condition, occurring in 0.1 to 0.2 per cent of young adults. The maldescended testis, sometimes called the aberrant migration of the testis, while uncommon, is rarer than simple cryptorchidism. In view of the importance of this pathologic entity, a review of the embryologic changes in the development of the testis might be pertinent.

Embryonic Development of the Testis.—During the early stages of development the genital glands, testicles or ovaries, are situated far forward in the abdominal cavity. During the eighth week they lie opposite the lumbar vertebrae. During the succeeding months, up to the time of birth, they gradually move caudally to the positions they occupy in the adult. This migration is brought about, to some extent at least, by the influence of certain bands of tissue which are primarily like mesenteries. As the mesonephros develops and projects into the body cavity, it comes to be attached along the dorsal body wall, lateral to the dorsal mesentery, by a sheet of tissue which is called the mesonephric mesentery. Cranial to the mesonephros, this mesentery is continued as the diaphragmatic ligament of the mesonephros, which as the name indicates, is attached to the diaphragm; caudally it is continued to the inguinal region as the inguinal ligament of the mesonephros (Fig. 1). The genital gland lies on the medial side of the mesonephros and is attached to the latter by a sort of mesentery which becomes the mesovarium in the female or the mesorchium in the male. The cephalic portions of the ducts (Mullerian and mesonephros) lie close together in a ridge on the lateral surface of the mesonephros: as they pass caudally they extend around the ventral surface of the mesonephros and approach the medial line, and finally, in the pelvic region, the two ridges meet and fuse, forming the so-called genital cords. The genital cord thus contains the mesonephric and Mullerian ducts, the latter fusing to form a single tube (the anlage of the uterus and vagina). It also contains the umbilical arteries.

Such a condition is found in embryos of about eight weeks. From this time on the processes of development follow divergent lines in the two sexes, the differences becoming more marked from month to month. Certain structures persist and others disappear, according to the sex. The mesenteries and ligaments undergo metamorphoses and the genital glands migrate caudally.

Descent of the Testis.—As the mesonephros atrophies, its mesentery and the mesentery of the testicle are combined to form a single band of tissue, which, of course, is continuous with the inguinal ligament. The latter now

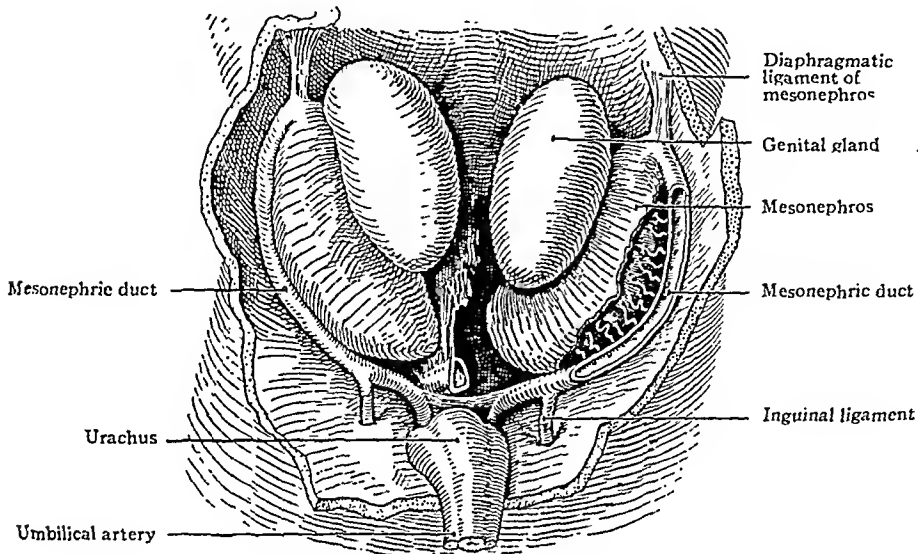


FIG. 1.—Urogenital organs in a human embryo of 17 Mm. (six weeks). (Kollman's Atlas.)

becomes the so-called gubernaculum testis (Hunteri), a strong band or cord composed of connective tissue and smooth muscle. Its cephalic end is attached to the epididymis, its caudal end pierces the body wall in the inguinal region

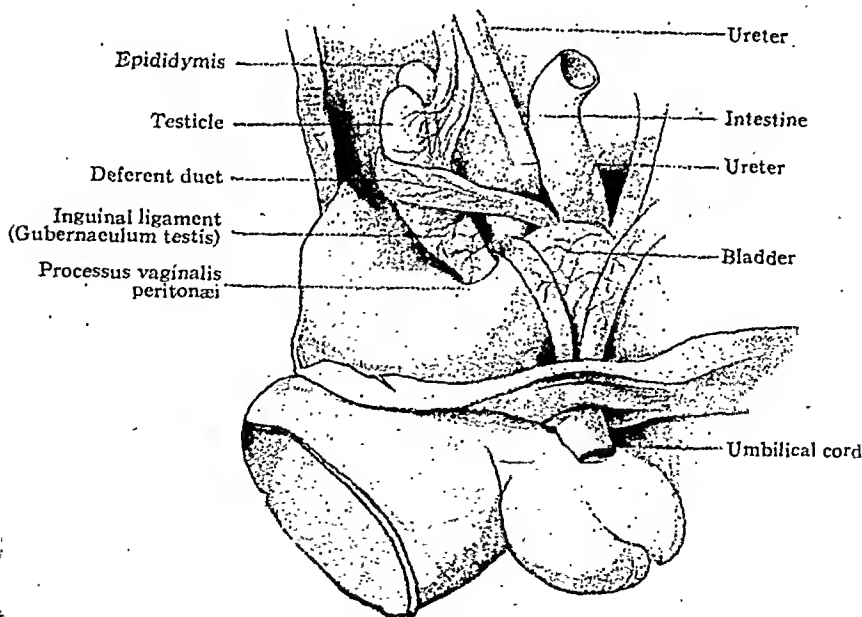


FIG. 2.—From a dissection of the pelvic region of a male human fetus of 21 cm. (Kollman's Atlas.)

and is attached to the corium of the skin (Fig. 2). It plays an important part in the descent of the testicle. The descent is brought about through the principle of unequal growth. As the body grows in length, the gubernaculum

grows much less rapidly and, since the caudal end of the latter is fixed, the natural result is the drawing downward of the testicle. This takes place gradually, and at the end of the third month the testicle lies in the false pelvis, at the end of the sixth month close to the body wall at the inguinal ring.

During the third month a second factor in the descent of the testicle appears. This is an evagination of the peritoneum at the point where the gubernaculum pierces the body wall. The evagination at first is a shallow depression, known as the processus vaginalis peritonei, but continues to burrow through the body wall and causes an elevation in the skin which is destined to become one side of the scrotum. The opening of the peritoneal sac into the body cavity is the inguinal ring. In its descent the testicle passes through the inguinal ring and comes to lie in the elevation in the skin or scrotum at about the ninth month. Whether its passage into the scrotum is the result of a traction by the gubernaculum is not certain. The inguinal ring then closes

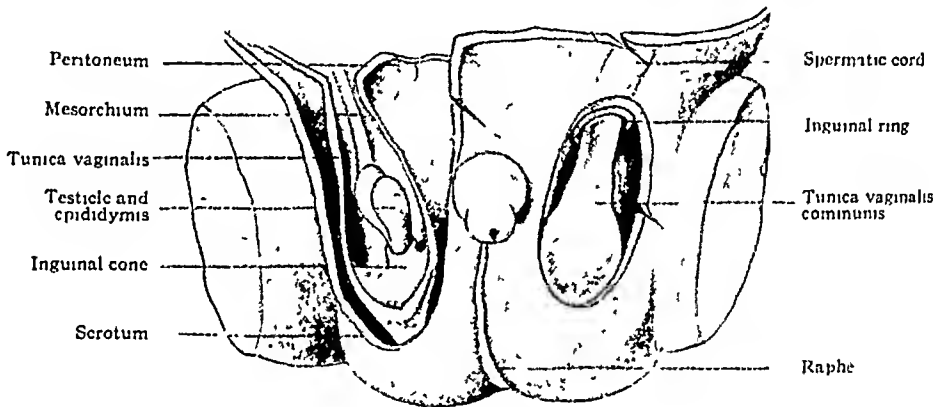


FIG. 3.—From a dissection of the scrotal region of a human fetus of 25 cm. (Kollman's Atlas.)

by apposition of its walls and the testicle lies in a closed sac which has been pinched off, so to speak, from the body cavity (Fig. 3).

Since the testicle is invested by peritoneum from the beginning of its development, it must be understood that in its passage into the scrotum it passes along under the peritoneum. Consequently when it reaches the scrotum it is surrounded by a double layer of peritoneum, the tunica vaginalis propria.

As a result of improper descent or failure of the testicle to take its proper course in the scrotum, certain anomalies occur, which can be classified anatomically as follows:

A. Nondescended Testis.—From the above description it is readily seen that the primary genital anlage of the testis is placed in close proximity to the primitive kidney. Before reaching its ultimate resting place in the bottom of the scrotum the testis must pass along the posterior abdominal parietes, through the inguinal canal and upper part of the scrotum. The testis may be arrested in any part of its course, and, in consequence, the following anomalies may be met with:

(1) The abdominal nondescended testis. The testis is arrested proximal to the internal inguinal ring.

(2) The inguinal nondescended testis. The testis is arrested in the inguinal canal.

(3) The pubic nondescended testis. The testis is arrested just beyond the external inguinal ring, *i.e.*, in front of the pubic bone.

(4) The upper scrotal nondescended testis. The testis is arrested in the upper part of the scrotum.

B. Maldescended Testis.—This variety differs from the preceding in the important fact that the testis is not arrested anywhere in its course. The organ is extruded through the external inguinal ring like a normal testis; at this point, however, it fails to take its proper course into the scrotum, and is deflected in other directions. When this occurs, we may have the following types:

(1) The inguino-superficial maldescended testis. The testis, after its extrusion from the external inguinal ring, is deflected upward and outward and lies upon the aponeurosis of the external oblique muscle, between it and the deep layer of the superficial fascia.

(2) The crural or cruro-scrotal maldescent of the testis. The testis lies in the upper part of Scarpa's triangle, or more frequently in the angle formed by the thigh and scrotum.

(3) The perineal maldescended testis. The testis, after its extrusion from the inguinal canal, migrates into the perineum.

(4) Transposition of the testis. In this exceedingly rare condition, the testis of one side migrates intraperitoneally, and is extruded through the opposite inguinal canal, into the opposite scrotal half. While this in effect is also a maldescent, it is not so in the strictest sense.

TORSION OF THE TESTICLE

Torsion of the testicle is a misnomer, and should really be called torsion of the spermatic cord, as this really gives a better description of the condition. There is an axial rotation or twist of the cord itself with a cutting off of the blood supply to the testicle and epididymis, resulting in local and general symptoms due to the inflammation and subsequent gangrene.

Incidence.—The number of cases of torsion of the testicle reported in the literature is really not a true index of the incidence of this condition. Prior to 1920 there were only 120 cases reported. Since then many others have been added, Campbell³ alone reporting 15 cases from Bellevue Hospital in a period of six years. The incidence of torsion of an intra-abdominal testicle, however, is quite low. Ormond,¹¹ in 1927, collected five cases from the literature, adding his own as the sixth. Since then four more have been added, which with the author's case makes 11 known cases of this condition thus far reported in the literature.

TORSION OF INTRA-ABDOMINAL TESTICLE

CASES OF TORSION OF AN INTRA-ABDOMINAL TESTICLE

Case	Author	Year	Side Involved	Presence of Malignancy	Ectopic Testicles
1	Gerster.....	1897	Right	Yes	Bilateral
2	Stiles.....	1905	Right	Yes	Unilateral
3	Le Conte.....	1907	Right	Yes	Unilateral
4	Howard.....	1907	Right	No	Bilateral
5	Cupler.....	1915	Right	No	Unilateral
6	Ormond.....	1927	Right	No	Unilateral
7	Pearlman.....	1927	Left	Yes	Unilateral
8	Wallenstein.....	1927	Left	No	Bilateral
9	S. Power.....	1933	Left	No	Unilateral
10	E. C. Chitty.....	1933	?—	Yes	?—
11	A. J. Beller.....	1934	Left	No	Bilateral

An examination of these cases shows that the left side is almost as frequently involved as the right, although up to 1927, in the series reported by Ormond, all the cases were on the right side. Since then all the additional cases have been found on the left side. It may also be noted that of the 11 cases, four had bilateral undescended testicles and in one this was not reported. Much has been said about the development of malignancy in undescended testis; of the 11 cases in the literature five had a malignant tumor in the affected side.

Etiology.—Torsion is more prone to occur in patients with undescended testicles than in patients with normally descended testicles. In an analysis of 150 cases of torsion, Wallenstein¹⁶ noted that 90, or 60 per cent, occurred in patients with either undescended or maldescended testicles. When one considers the incidence of ectopic testicle in relation to those normally descended, this figure becomes much higher.

There are four anatomic factors which play an important rôle in the causation of torsion of the testicle: (1) Abnormally loose scrotum; (2) voluminous tunica vaginalis; (3) unusually long gubernaculum or retained lengthened mesorchium; (4) abnormal attachment or location of the cord. From a consideration of the anatomy and the recorded cases, the last two factors appear to play the most important part in torsion of abdominal testis. Moschcowitz^{9, 10} has pointed out that in the maldescended testicle, the cord structures are normal in every respect excepting location. Thus the vas deferens is of ample length and consequently cannot be given the primary rôle in maldescent of the testis.

The factor precipitating torsion in all of the cases presented has been a sudden strain usually occurring in the normal routine of the patient. The onset has always been sudden.

Symptoms.—In all of the cases reported the symptoms had continued more or less acutely up to time of operation. (In Stiles'¹⁵ case, four acute attacks were noted before operation with periods of freedom from symptoms.) In none had a rectal mass been palpated and in only one instance (S. Power¹³) was rectal tenderness noted. In the case to be presented, it

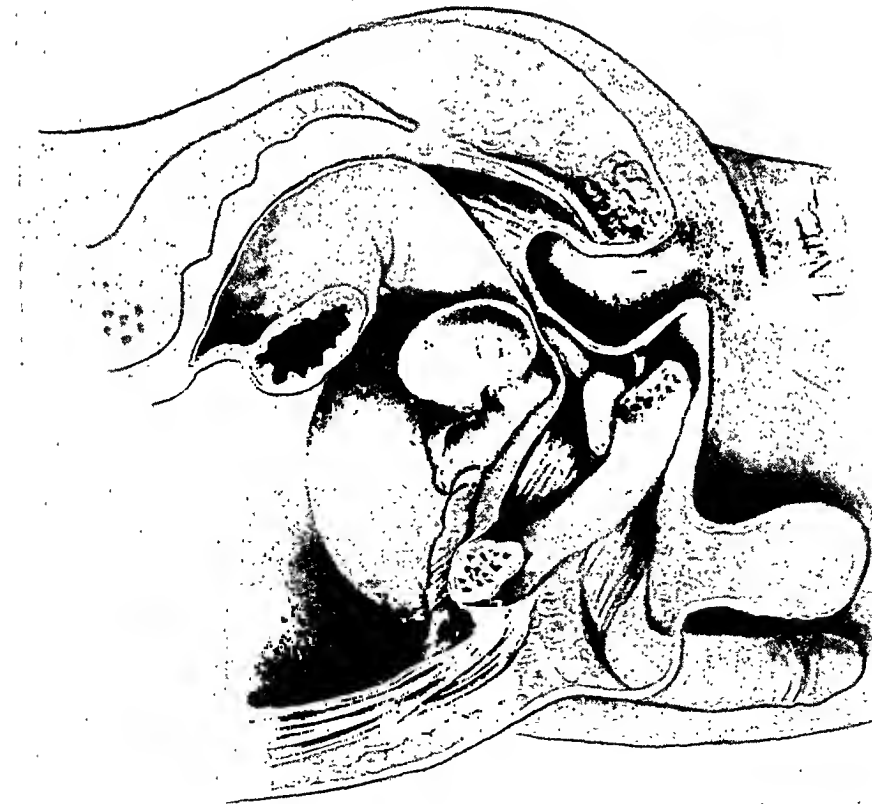


FIG. 4.—Showing torsion of the left testicle with its pedicle emerging just above the internal inguinal ring and the relationship of the testicle to the rectum and bladder.

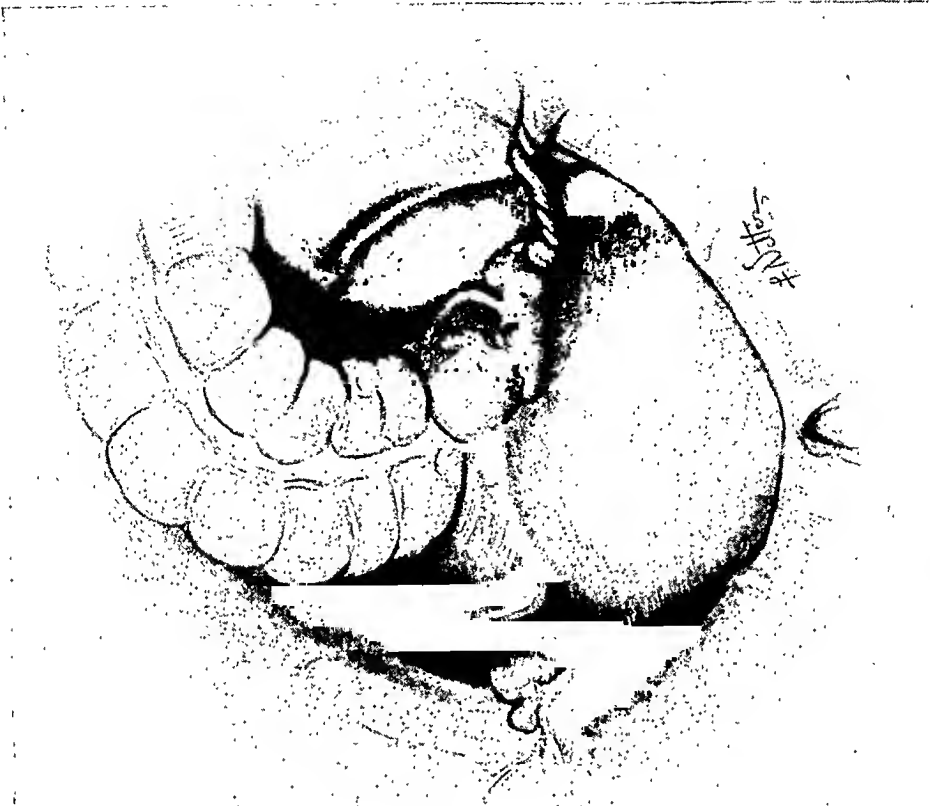


FIG. 5.—Showing bilateral intra-abdominal testes, a small right one and a much enlarged gangrenous left one, due to the torsion of the cord.

will be seen that symptoms disappeared entirely within eight days after onset, and a rectal mass with tenderness was present.

The disappearance of pain following onset of gangrene with torsion was noted by Meredith Campbell³ in patients with torsion of the testicle in sites other than abdominal. Wallenstein¹⁶ in presenting the eighth example of the syndrome reviewed the cases as to symptomatology, mode of onset, *etc.*

CASE REPORT.—L. E., 28-year-old white male, entered Mt. Sinai Hospital with the complaint of pain in both lower quadrants, more marked on the left side. The pains were rather sharp and sticking in character, and seemed to radiate over the entire abdomen. They were relieved somewhat by lying down and aggravated by physical exertion, and after eating. There was no associated nausea or vomiting. Since the onset of his illness there had been no spontaneous bowel movements but daily enemata had returned brown fluid with little feces. There were no significant findings in his past history.

In the physical examination the findings of importance were moderate abdominal tenderness in both lower quadrants more marked on the left where voluntary rigidity was also present. The testicles were not in the scrotum or in the inguinal canals. Rectal examination revealed a small prostate just above which a small, soft, tender mass could be palpated on the left side. Its limits could not be definitely determined.

The patient volunteered the information that his testicles had never descended. He has been married three years; sexual intercourse was satisfactory but sterility present. Secondary male sex characteristics were normal; beard and male hair distribution were present.

Temperature was 100.2°, returning to normal in a few days. The white blood count was 8,000 with a normal differential. Hemoglobin was 70 per cent. Sigmoidoscopy.—Instrument could be passed only 15 cm. at which point there was an obstruction due to a small tender mass the nature of which could not be determined. Roentgen ray reports.—Flat film of abdomen revealed no pelvic mass. Barium enema revealed no obstruction, constriction, or filling defect. Intravenous pyelogram taken to determine the presence of a possible ectopic pelvic kidney revealed normal kidneys, ureters and bladder. An Aschheim-Zondek test done to eliminate the possibility of teratoma was negative.

Ante-operative Course.—The symptoms gradually diminished and disappeared entirely within about five days with bed rest. The rectal mass was still moderately tender and had not changed in size. Foreign body perforation, metastatic tumor, and torsion of an intra-abdominal testicle were considered. From the history and physical signs of the case, the persistence of the rectal mass, and the absence of testicles in either the scrotum or inguinal canal, the author was led to suspect that the diagnosis of a torsion of an intra-abdominal testicle was a possibility. Exploratory laparotomy was performed 20 days after his admission.

Operative Findings.—The pelvis contained a small amount of old blood. Occupying the left side of the pelvis was a mass to which were adherent the bladder in front, the



FIG. 6.—Specimen of left testicle, epididymis, and pedicle after removal.

sigmoid above and the rectum below (Fig. 4). After freeing the mass, it was found to be an intra-abdominal testicle suspended above the internal ring by a pedicle consisting of cord structures surrounded by peritoneum. This had been twisted about one and one-half times on itself and appeared bluish-black, swollen and gangrenous. A left epididymo-orchidectomy was performed. Examination of the right testicle revealed it to be lying freely in the peritoneal cavity attached by the cord structures above the internal ring on that side (Fig. 5). Postoperative course uneventful.

Pathologic Examination.—Doctor Otani reported the specimen to consist of a testicle, epididymis, and a portion of the vas. The specimen at the time of description has been fixed and reveals a torsion of the vas as though on a twisted pedicle. This is approximately 5 cm. above the upper pole of the epididymis. The epididymis is hemorrhagic and enlarged so that the width approaches about 2 cm. and its length 5 cm. The testicle also is distended as though infarction had taken place. It measures $5\frac{1}{2}$ by 4 by $3\frac{1}{2}$ cm. (Fig. 6).

SUMMARY.—(1) This is the eleventh case of torsion of an intra-abdominal testicle to be reported.

(2) It presents several unique features:

(a) The testicle had fallen into the pelvis and was palpable as a tender mass per rectum.

(b) The symptoms ceased within eight days of the onset.

(c) Operation was performed 23 days after onset of symptoms.

(3) This case adds to the list another left-sided torsion of an intra-abdominal testicle making the left side almost as frequent as the right in the cases reported to date.

(4) Five of the 11 cases which have been reported have shown the presence of malignancy.

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RUPTURED PYO-URACHUS COMPLICATED BY URETHRAL STRICTURE

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THE name "pyo-urachus" was first introduced by Stevens¹ as a substitute for the term "abscess of the urachus." He based this designation upon the histologic evidence obtained from serial sections of the specimen of his case. A careful search of the literature fails to indicate another case similar to the one here to be reported; namely, a case of pyo-urachus rupturing into the groin and complicated by an urethral stricture. In 1931, Deneen and Margold² reported a case of urachal-cyst abscess, uncomplicated by stricture, which had ruptured into the peritoneal cavity.

The general consensus of opinion among anatomists is that the urachus takes origin from the ventral cloaca or bladder. In evidence of this origin is the similarity of the epithelial surfaces, and the muscular and fibrous coats of the urachus and bladder. Just prior to birth the bladder is situated in the region of the umbilicus and in its descent toward the symphysis pubis there occurs an outgrowth at its apex; and it is this tubular extension or outgrowth which is designated urachus. Among the chief exponents of this view are Robinson³ and Felix.⁴ Keith,⁵ on the other hand, maintains that the urachus arises from the fetal allantois. This latter view was held until recent years. The remains of the allantoic stalk may be identified in the adult at the upper end of the urachus in the form of fibrous strands or cords (Luschka's plexus) which lie in the mid-line in association with the obliterated umbilical arteries. In the foetus these strands pass through the umbilicus into the umbilical cord.

R. C. Begg⁶ studied a series of twenty-eight urachal specimens from still-born foetuses and from preserved cadavers which were obtained from the postmortem room. He demonstrated that the epithelial lining of the urachus never becomes completely obliterated to form a solid cord, but that its lumen or central canal persisted and in 33 per cent. of the cases communicated with the vesical lumen. Luschka⁷ demonstrated that the urachus practically never reaches the umbilicus in the adult as a cord, but rather frays out into a number of fine thread-like strands before reaching that point.

The average distance from the bladder to the umbilicus is seventeen centimetres. The average length of the urachus is 5.5 centimetres. It is widest at its lower end, about eight millimetres, and at its apex measures approximately two millimetres. It is situated between the peritoneum and transversalis fascia, being more freely movable near its lower end where it is in contact with the bladder. At its upper end it is more firmly adherent

to the peritoneum and transversalis fascia. The blood supply is derived from one of the superior vesical arteries which courses along its ventral aspect.

As stated above, it is to be noted that the urachus, instead of being a completely obliterated cord, is actually a cord-like structure presenting a central canal which remains patent throughout life. At times, parts of the canal may become occluded with masses of desquamated epithelial cells. Should a direct communication exist between the lumen of the bladder and the urachus, these cells may be expelled into the bladder. At other times the canal may become segmentally blocked resulting in sacculations, and in the event of secreting cells existing in the lumen of the urachus, actual cysts may develop. Occasionally the epithelial cells show a tendency to spread laterally into the connective-tissue layers of the anterior abdominal wall, forming adenomatous-like structures, cysts and calculi. Organisms may enter the lumen of the urachus by direct extension from the skin or bladder, or they may be transported there through the blood-stream. In either event an infected urachus results.

The urachus with its lumen measuring approximately one millimetre in diameter extends from its upper end below the umbilicus down to the bladder where its lumen may communicate directly with that of the bladder. On the other hand, it may end blindly, losing itself in the submucosa or muscular layer of the bladder. A cross-section of the urachus in its most fully developed part would reveal several layers, the innermost consisting of irregular transitional epithelial cells surrounded by layers of loose and dense connective tissues which in turn are invested with a muscular layer. The adventitia which is also composed of fibrous tissue surrounds the urachus.

The normal urachus gives rise to no symptoms. It is, however, prone to pathologic changes such as infections, diverticula, calculus formations and new growths. Urachal disturbances occur more frequently in the male than in the female in the ratio of five to one (Squier and Cahill⁸). A review of the cases of pyo-urachus reveals the fact that in most instances there was a concomitant vesical or infravesical obstructive lesion such as a neoplasm, calculus, urethral stricture, prostatic hypertrophy, vesical neck contracture or median bar. In some of the reported cases, however, no evidence of obstruction could be ascertained. Where such an obstruction exists in the presence of a direct communication between the urachus and the bladder, a pyo-urachus is likely to develop. Urinary stasis is an important contributing factor in the formation of pyo-urachus. In cases where no direct continuity between the lumen of the urachus and bladder exists, organisms may be carried in by way of the lymphatics or blood-stream as demonstrated by Begg.

The diagnosis of pyo-urachus in the simple and uncomplicated cases can be made with little difficulty. The presence of a tender triangular-shaped mass in the hypogastrium accompanied by urinary disturbance such as dysuria, hæmaturia, pyuria, frequency and fever in the presence of a vesical or infravesical obstruction is extremely suggestive of pyo-urachus. Occasionally one

may find a few drops of urine at the umbilicus coming from the bladder by way of the urachus and Luschka's plexus.

Cystoscopic examination usually reveals the presence of a diffuse cystitis with a small reddened edematous area at the vault of the bladder which corresponds to the urachal opening. When pressure is applied to the suprapubic mass, one may note a ribbon of pus extending into the bladder from its vault. Occasionally one may be able to pass a fine catheter for a short distance through the urachal orifice. At times cystoscopy may reveal the causative factor in the production of the pyo-urachus. The higher incidence of this anomaly in males is presumptive evidence of the rôle played by obstruction in the formation of pyo-urachus. The diagnosis of pyo-urachus presents no unusual difficulties, especially when it is borne in mind that any cord-like structure extending from the symphysis pubis upwards toward the umbilicus may be due to a patent urachus.

It is not unusual for an infected urachus to rupture into the peritoneal cavity. Such cases were recently reported by Deneen and Squier. In the case of the former, the patient died of general peritonitis. A pyo-urachus may perforate through the umbilicus by way of Luschka's plexus and establish an external fistula, or it may rupture into the groin by burrowing through the fibromuscular and connective-tissue layers.

Treatment which is always operative should be instituted early. Complete extirpation of the tract including the peritoneum and umbilicus should be carried out in all cases. When the bladder is involved, as it usually is, the contiguous part of the vesical wall should be included in the extirpation. When infection has spread to the groin, wide-open drainage is indicated. The early institution of surgical intervention usually leads to recovery. Fatalities result from complications following failure to provide early drainage.

CASE REPORT.—S. K., male, aged fifty-one, married, was first seen in consultation November 21, 1933, complaining of severe pain over the lower abdomen of three days' duration. One week prior to admission to the hospital he experienced a chill and rise in temperature with pain localized to the right groin. A physician who saw him at that time attributed the condition to inguinal adenitis resulting from a ringworm infection of the toes. He was put to bed and cold compresses were applied to the groin. The fever and chills, however, persisted. Three days ago the pain extended to the right iliac fossa and to the suprapubic region. It was noted that the pain was aggravated on motion and absent when the patient was lying on his back. There was no vomiting, but a history of constipation. Urinary symptoms were absent save for a slight frequency, every two hours. There was no history of cough, dyspnoea, or cardiac distress. The family history was essentially negative. About ten years ago he was treated for a gonorrhoeal infection. During the past few years he had an epidermaphytosis involving both feet.

The patient was an obese male appearing acutely ill. Temperature on admission to the hospital was 104° F., pulse 118 and respiration 32. Examination of the head, neck and chest revealed no pathology. Blood-pressure was 130 systolic and 80 diastolic. There was a fulness to be seen in the suprapubic region; and the entire lower abdomen was tender and rigid. Rebound tenderness was elicited. The right inguinal glands were slightly enlarged but not tender. The liver and spleen could not be palpated. During catheterization it was noted that there was a filiform stricture of the membranous

urethra. Rectal examination showed no pathology. Urinalysis revealed a faint trace of albumin. Blood count: 15,300 leukocytes with 74 per cent. polymorphonuclears and 26 per cent. lymphocytes. Hemoglobin, 95 per cent. (Sahli).

Because of the history of ringworm infection with inguinal adenitis preceding the onset of the acute surgical abdomen, it was believed that the patient might have a suppurative adenitis involving the nodes of the pelvis and that this was responsible for the spasticity of the abdominal muscles. An internist, who was called in to see the patient, believed that he detected the greatest amount of tenderness and rigidity to the

left of the mid-line, which led him to the conclusion that we were dealing with an acute diverticulitis of the sigmoid, and that the history of the preceding inguinal adenitis was purely coincidental. The necessity for an abdominal exploration was accentuated by the progressive increase in abdominal tenderness and rigidity, and a marked increase in leukocytes to 22,000.

Operation.—(J. A. L.) November 21, 1933, under spinal anaesthesia (tropococaine 10 per cent.) an exploratory laparotomy through a three and one-half inch mid-suprapubic incision was performed. Upon approaching the anterior parietal peritoneum, a large triangular mass was felt extending from the symphysis pubis towards the umbilicus, and attached to the anterior peritoneum. The peritoneal cavity was opened through an incision carried down to the right of this mass. Exploration of the sigmoid and pelvis showed no abnormality; the peritoneal cavity was not infected. Following closure of the peritoneum, the mass previously described was carefully dissected and on approaching its lower extremity pus was seen exuding from a small perforation in its lower portion and extending downwards towards the space of Retzius and outwards beneath the right rectus muscle towards the right groin. The bladder felt thick and indurated, and an attempt to aspirate it by means of a needle was unsuccessful. A



FIG. 1.—Gross appearance of specimen removed at operation

catheter could not be made to pass into the bladder per urethram. The infected mass was stripped away from the bladder and space of Retzius. A specimen of the pus was taken for culture. An iodoform pack and two tubes were introduced into the space of Retzius and another tube was placed behind the right rectus muscle. The wound was closed in layers.

For seven days after operation the clinical course was uneventful. On the eighth day the patient was unable to urinate. He was catheterized but no urine was obtained. From that time his condition grew progressively worse. The abdomen became distended and he developed complete anuria which failed to respond to intensive treatments. He died in uræmic coma on the nineteenth day after operation.

Examination of the pus obtained at operation revealed a pure growth of *Streptococcus hemolyticus*.

Pathologic Report.—The specimen consists of a rectangular sheet of soft tissue (Fig. 1). It measures eight by five by four centimetres and is composed of a fibro-

FIG. 2.—Low-power photomicrograph showing the character of the urachal wall completely infiltrated with leukocytes



FIG. 3.—High-power photomicrograph showing the wall of the urachus completely destroyed by leukocytic infiltration.



fatty outer envelope and is penetrated by a continuous canal running throughout its entire length. The canal is irregular and partly filled with numerous granular fragments of tissue. This cavity or canal in its widest part is two centimetres. A few small blood-clots were present within its lumen.

Sections show a uniform histologic picture (Figs. 2 and 3). There is a considerable amount of fatty tissue which is surrounded by a diffuse necrotic infiltration composed largely of neutrophilic leukocytes with an occasional plasma cell and a moderate number of mononuclear cells. There is a moderate hemorrhagic infiltration, and occasionally one sees a thickened vessel filled with erythrocytes. The fibrous connective tissue on which the fatty tissue rests is congested, edematous and riddled with inflammatory exudate.

SUMMARY.—(1) A careful review of the literature fails to reveal a single case of a pyo-urachus rupturing into the groin.

(2) The urachus is a developmental anomaly originating from the cloaca or bladder, and not the allantois.

(3) The urachus is prone to pathologic changes.

(4) The diagnosis of pyo-urachus is usually not difficult. A tender suprapubic mass accompanied by vesical or infravesical obstruction and urinary disturbance helps to identify this anomaly.

(5) Treatment is surgical and should be instituted as soon as the diagnosis is made.

CONCLUSIONS.—The case here presented is one of pyo-urachus associated with a filiform stricture of the urethra which had perforated and infected the space of Retzius and the right groin. The infected nodes felt in the groin, which were at first interpreted as being due to the epidermophytosis of the foot, were really secondary to the pyogenic infection which had extended behind the rectus muscle to the tissues of the right groin.

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SYMPOSIUM
ON
CARCINOMA OF THE RECTUM

AT
THE FIFTIETH ANNIVERSARY OF THE MEMORIAL
HOSPITAL

NEW YORK, N. Y. MAY 25, 1934

Chairman, GEORGE E. BINKLEY, M.D.

ETIOLOGY AND DIAGNOSIS OF RECTAL CANCER. EDWARD G.
MARTIN, M.D., Detroit, Mich.

PATHOLOGY OF INTESTINAL CARCINOMA. JOSEPH FELSEN,
M.D., New York, N. Y.

ONE STAGE ABDOMINOPERINEAL OPERATION FOR CARCI-
NOMA OF RECTUM. THOMAS E. JONES, M.D., Cleveland, Ohio.

TWO STAGE OPERATION FOR CARCINOMA OF RECTUM.
FRANK C. YEOMANS, M.D., New York, N. Y.

GOLD RADON SEEDS IN RECTAL CANCER. GEORGE E. BINKLEY,
M.D., New York, N. Y.

EXTERNAL IRRADIATION IN RECTAL CANCER. JAMES J. DUFFY,
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PREDISPOSING FACTORS AND DIAGNOSIS OF RECTAL CANCER

(A DISCUSSION OF ALLERGY.)

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AFTER the development of the first achromatic microscope at Paris in 1824, more than 40 years elapsed before the fundamental fact was proven that cancer was an atypical proliferation of epithelial cells. Records suggest that the Egyptians operated upon growths with hot cautery, and treated them with arsenical pastes in 1500 B.C. One thousand years later, Hippocrates described cancer in the breast and cancer of the internal organs. Galen founded experimental physiology and pathology about 200 A.D., and his opinion prevailed until late in the eighteenth century. Many theories were advanced as to the cause of cancer, and approximately 1,000 years passed before Galen's views, that strong black bile was the principal causative factor, were questioned. Virchow, who founded the science of cellular pathology, finally introduced the accepted conception of the histogenesis of tumors, and brought their study from chaos to an orderly science. His conception that cancer cells originated from connective tissue prevailed until Thiersch and Waldeyer disproved the theory in 1865-1867.

Heredity presents an intriguing study; however, after a review of opinions and quoted statistics, I am constrained to report that heredity in humans as regards the major forms of cancer, is as yet unproven. I say "constrained" because if cancer were hereditary, at least we might hope, by sterilization, to legislate it out of existence. In 3,000 cases from Middlesex Hospital, Hillier and Tritsch found a family history in 13.1 per cent, while the control group showed an incidence of 14 per cent. German statistics indicate even less, 9 and 10 per cent respectively in more than 9,000 patients—male and female. Much may yet be learned, however, about heredity.

Congenital or acquired predisposition, it seems to me, may be tentatively accepted and considered from an allergic or idiosyncratic standpoint. We do describe oil, tar, aniline dye, arsenic, roentgen ray and radio-active-substance cancers, also lung malignancies, ascribed to inhalation of various dusts. Under what seem identical circumstances, one person will develop carcinoma, while another does not. From 40 to 60 per cent of persons with multiple adenomata of the rectum develop cancer; why—no one knows. May the conception of allergy or idiosyncrasy be broadened to include this mysterious fact? If cancer develops as the result of a peculiar individual susceptibility, might that explain the confusion of false positives in some of the serodiagnostic tests? I confess incompetency to answer my questions. Hellwig¹ in discussing pre-cancerous lesions states:

"No morphologic method can decide whether a noncarcinomatous atypical cell proliferation will actually develop into cancer or prove to be entirely harmless. The deciding factor, when such a lesion results in a malignant tumor, is apparently an individual predisposition, the nature of which is unknown."

While Rankin² in referring to adenomatous polyps says that:

"... whether they are the result of inflammatory change or true neoplasm . . . after they reach a certain point in development and are subjected to certain (it must be admitted) unknown factors which initiate the malignant drive, (they) may result in identical processes which develop into malignant growths."

It is now generally conceded that rectal adenomatous polypi constitute the most dangerous, as well as the most common predisposing factors in the development of rectal adenocarcinoma.

Rankin and Fitzgibbon,² in 1931, traced thirteen of these cases through the sequence of events from a benign to a malignant condition, and reviewed the histopathologic characteristics of the polyps and were able to show conclusively that they were not all of a piece, but that in this series there was definite progression from benignancy to malignancy. They were divided into three distinct groups, varying grossly as well as microscopically.

In GROUP I, the epithelial elements were found to deviate little from the normal. The tumors are represented by rough, nodular elevations on the mucous surface of the bowel, varying in size from tiny clubs not much larger than a pin point to masses 2 cm. on cross-section. It is conceivable that this type of polyp may become malignant, but there is little evidence that it has a tendency to such change. It is interesting to speculate on the normal presence of such polyps in a bowel regarded as normal from the standpoint of function and symptoms. Certainly, such lesions are found most frequently in the mortuary, and lead one easily to the suspicion that a great many, perhaps most, colons, harbor such deviations from the normal mucosa.

In GROUP II, the polyps are distinctly different, not only grossly but microscopically. Their structural changes in both epithelial and connective tissue elements are abrupt, striking, and characteristic. The epithelial elements fail to differentiate into normal intestinal mucosa. The cells are elongated, and by their increased bulk are compressed laterally. Their arrangement may be in single rows, but frequently they are found pushed into multilayered buds, and project into the lumen of the tubules or into the connective tissue matrix. The nuclei are different in that they are more elongated than normal and are stained more deeply. As those epithelial proliferative processes progress, they stimulate a corresponding response in the connective tissue of the underlying growths, resulting in the production of a stalk which gives the polyp its pedunculated appearance. The time of the proliferation influences, according to its rapidity, the general anatomic scheme of the polyps, so far as the pedicles are concerned, making them large or small, and is, I

believe, an extremely important point in the metamorphosis of polyps to carcinoma. The carcinomata resulting from this group of polyps usually are of the pedunculated type, which, growing toward the lumen of the bowel and presenting themselves as piled-up masses of adenomatous tissue, may grow to huge size before malignant metamorphosis is completed. By their very presence they may be the initiating factor in intussusception or obstruction, thus calling attention to themselves. Fortunately, they usually are of a relatively low grade of malignancy or of average malignancy, one might say, and the prognosis, in that they do not project downward and backward to the nodal regions, is more likely to be favorable.

In GROUP III the polyps show almost complete failure of differentiation of their epithelium. In reality, GROUP III is an advanced and accentuated form of GROUP II. The proliferative epithelial element, which outpaces that of connective tissue, results in a complex polyp histologically, which usually is sessile and infiltrating. They may or may not attain large size and age, usually forming the smaller, more punched out, rapidly growing and metastasizing types of malignant growth. They proceed toward the peritoneal coat rather than toward the lumen, and in this way invade the nodal structures more often than the other types.

While excluding boldly other rectal and anal abnormalities or diseases, as not having any very important immediate bearing on the development of rectal cancer, Rosser's³ observations suggesting anal pathology as an inciting factor in local tissue predisposition, should be mentioned. In a series of 13 cases of anal cancer, in 12 benign anal pathology was believed to have been present before the onset of malignancy and to have brought about a local tissue predisposition. The benign lesions present were fistulae (seven cases), hemorrhoids (four cases), infected crypts with papillitis (one case). In a subsequent review of eight cases of fistula, he believes that the criteria which he sets up warrant the assumption that they acted as an etiologic agent in inciting cancer.

It seems quite logical to exclude the anal region as of minor importance if one points to the comparative rarity of anal malignancy—perhaps two per cent, and what may be considered the almost universal occurrence of anal disease—perhaps 85 per cent. Rectal cancers are usually nearer the ampulla of the rectum than the anus, or at the rectosigmoid juncture.

Diagnosis.—Remarkable and most commendable study is being given to serodiagnosis; this study, however, remains unfinished, and the results so far inconclusive. The finding of the so called precancer lesion, the adenomata, is much more important than the discovery of the later carcinoma, since the treatment offers very much more favorable prognosis by less radical or devastating treatment. Although routine rectal examination (proctoscopy) may be more than can be expected, as yet, judging by current and past experience, it remains an undisputed fact that the majority of rectal cancers

could be prevented and cancer mortality tremendously decreased, if such a procedure were common practice. Proper digital examination will disclose the majority of rectal carcinomata, and were even this procedure common practice it will not be denied that cancer mortality would be tremendously lessened. By "proper," I mean that the patient should be required to "strain down," with the index finger inserted full length as though effort were being made to move the bowels; the rectosigmoid juncture can thus ordinarily be reached and explored. I inform students that if they feel anything except the smooth rectal wall, further investigation should follow; I also stress that hemorrhoids cannot be felt. When any complaint referable to the anorectal region is made and a physician fails to make a digital examination he is guilty of gross negligence. I would estimate that approximately 75 per cent of the profession are thus guilty, and so responsible for the large number of *advanced* cancer cases that are finally examined.

Mr. Ernest Miles of London believes that a latent period exists for a year or so prior to objective symptoms of cancer which is accompanied by a prolonged and well marked attack of constipation; that after an interval of from three to six months there follows diarrhea, slight at first and gradually becoming more pronounced. The constipation results from an induced inertia of the colon, and does not respond satisfactorily to treatment; there is no abdominal distention as in the later obstruction. Thus he defines in the Letsonian Lectures of 1923 this remarkable and now generally accepted prodromal symptom or sign—change in bowel habit.

Carcinoma at the rectosigmoidal junction rapidly involves the circumference and owing to the early stenosis produces obstructive symptoms. In the papilliferous variety there is excessive mucus secretion and diarrhea, becoming increasingly more marked; the stools are stained with blood, but real hemorrhage is unusual except as necrosis ensues. Obstruction finally follows as the result of impacted feces or local intussusception. The adenocarcinoma rapidly infiltrates the entire circumference and announces its presence by obstruction, often without bleeding or diarrhea.

Carcinoma in the Ampulla.—When discovered early, it is by incidental or routine examination since the growth causes no subjective symptoms at that time. In the occasional exuberant papilliferous variety, the sensation of fullness may excite attention; this may occur before any sign, such as a copious mucus discharge, appears; blood comes into the picture with surface disintegration. The adenocarcinoma, by far the more frequent and more malignant, involves the mucous and submucous membrane; it usually appears as a sessile growth and is at first freely movable, but after a few months infiltrates the muscular wall. Surface ulceration occurs with increasing growth and the flattened surface finally yields, and the crater-like ulcer develops. With the spread of this destructive ulceration, the usual subjective and objective symp-

toms develop, with frequent mucous stools tinged with blood and having the characteristic foul odor of rectal cancer. I have examined patients in whom the crater-like ulcer had involved almost the entire excrescence of the tumor; then I have found the crater plastered with fecal matter, leaving a smooth and confusing surface. It is somewhere in this stage that the patient and his doctor conclude that something besides suppositories ought to be done about his "piles."

In explanation of some of the symptoms it may be stated that hemorrhage at this stage is usually due to accompanying hemorrhoids except where a vein may have ruptured by necrosis; the excessive mucus is due to proctitis and the odor to necrotic tissue mixed with blood and mucus. Pain during and after defecation indicates encroachment into the anal canal. "Dull ache" describes the later pain of a midampullary carcinoma. Frequent stools occur in the daytime owing to the upright position.

Anal carcinomata, although frequently mistreated for anal ulcer, cause such early and excruciating pain that they are usually presented for examination while still operable. This is the most infrequent location of the rectal cancer; the diagnosis obviously should not be difficult.

Differential Diagnosis.—Confusion may result when an intussuscepted papilliferous colon growth is discovered in the rectum; since the tumor is not attached to the rectal wall, although it may conceivably fill the rectum, its source should thus be determined. Miles describes the villous papilloma as feeling like a mass of mucous membrane; an exuberant growth attached to the rectal wall by a narrow hand-like pedicle extending from one end of the growth to the other, at times resembling attachment as by a mesentery. It has a characteristic watery secretion necessitating frequent evacuation. I have seen but two such growths. A simple adenoma is soft, nonindurated, and finely lobulated, while the malignant adenoma is indurated and feels generally firm on digital examination. They may be pedunculated or sessile.

The value of biopsy in diagnosis is not now debatable. If positive for malignancy, its value for prognosis involves the disclosure of histogenesis, degree of malignancy, radiosensitivity, and perhaps metastasizing possibilities. Discussion of biopsy should be an essay in itself, and I will simply emphasize that aseptic and antiseptic precautions should be observed. It is advisable to excise the entire suspected area when practicable, thereby accomplishing the double purpose of eradication and diagnosis. A specific or differential stain for cancer would be of inestimable value and simplify pathologic diagnosis; it is an objective well worth the efforts being made to attain it.

In summarizing, may I say that the adenoma is, within our limited knowledge either the principal agent or the principal factor predisposing to rectal cancer, and that the responsibility for reduction in the mortality from rectal cancer lies with the average physician. Thoughtful consideration

should be given the hypothesis that cancer results from an individual susceptibility to an unknown factor which initiates the pathological process.

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THE PATHOLOGY OF INTESTINAL CARCINOMA

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THE close relationship of the adenomatous polyp to carcinoma of the large bowel has been stressed by many authors, some of whom are of the opinion that all carcinomata of the colon or rectum originate in polyps (Versé, Westhues, Fitzgibbon and Rankin). Without entering into any controversial discussion, this viewpoint has been misconstrued by many to indicate that all polyps tend to become malignant. This is certainly not true, for multiple, silent, benign polyps of the large bowel are relatively frequent if carefully sought for at the autopsy table. The condition of diffuse polyposis of the large bowel, which may perhaps be more properly referred to as adenomatosis coli, appears to have an underlying pathogenesis different from that of the simple isolated polypoid adenomata. There is a definite familial character of the Mendelian type and a distinct tendency to malignant degeneration, often of multicentric character. In some cases adenomatosis coli appears to be an exaggerated response of the intestinal mucosa to an irritant, possibly infection, taking the form of multiple, closely packed, focal areas of epithelial hyperplasia. In an excellent example of this disease, involving the entire colon, the earliest lesions appeared as slight localized thickenings of the mucosa, often not larger than a pinhead, flat, and scarcely visible to the naked eye. Pedicle formation occurs at a late stage when the adenoma is quite fully developed, though still very superficial. The intestine attempts to expel the tumor as it would a foreign body and thus by reason of a loose mucosa, the adenoma acquires a pedicle, often of surprising length. Polyps with long pedicles rarely become malignant. Those with very short pedicles quickly become sessile, flat, and broad, when malignancy supervenes. I have never seen disappearance of coexisting benign polyps after removal of a carcinoma. In reviewing the general subject of intestinal tumor pathology, one cannot but be impressed with the fact that simple polyposis as well as adenomatosis coli seems to occur in intestines which possess underlying pathologic tendencies. Thus,

one may see such associated conditions as villous tumor, diverticulosis or congenital anomalies.

Classification of carcinomata of the rectum into projecting, infiltrating and stenosing types is simple and practical, but these often represent different stages in the same pathologic process. As a general rule, the projecting types are fairly slow growing and are prone to undergo necrosis, but tend to remain local and rather superficial. Most Grade I tumors are of this type. The infiltrating and stenosing carcinomata tend to be more anaplastic. Mucin production is no certain criterion of the degree of malignancy. It merely represents an exaggerated physiologic activity of mucus-producing cells in cancerous tissue. Metastases do not always conform to the general rule of intestinal carcinoma—*i.e.*, the tendency to maintain the same structural type as the original tumor. I have not infrequently seen marked anaplasia in metastases, making it impossible to identify the site of the original, well-differentiated tumor. Briefly, it may be stated that the growth of intestinal carcinomata is relatively slow, depending, of course, upon the degree of anaplasia. In general, it may be said that carcinomata in the colon are more anaplastic than those in the rectum. With increasing anaplasia, there is a tendency to earlier age incidence and greater radiosensitivity, but a correspondingly poorer prognosis with regard to duration of life.

The grading of biopsy material should be done with caution. It is advisable to take specimens from (*a*) the growing edge, (*b*) the ulcerated floor, (*c*) the superficial projecting portion of the tumor in each case. In papillary tumors, especially, the biopsy must be taken from the base. I have repeatedly noted discrepancies in grading specimens taken from different portions of the same tumor and in one papillary tumor, there was no histologic evidence of malignancy, thought grossly carcinomatous, until a section was taken from the base.

Lymphatic extension may occur in any grade after the neoplastic process has reached the submucosa. Within the gut wall this occurs in two ways: annular, by involving the large circular intermuscular lymphatic plexus, and by wedge shaped extensions towards the peritoneum. Enlarged lymph nodes, though often inflammatory, should always be viewed with suspicion, especially in the nonulcerative types of tumor. The pathologist must dissect away the epiploic fat and feel for involved nodes with ungloved fingers, as otherwise they may be overlooked. There is a certain similarity between carcinoma and ulcerative disease of the intestine, such as bacillary dysentery, amebiasis and tuberculosis. In all, the lymphatic structures are extensively involved and serve as channels for dissemination of the disease. The tendency for tuberculosis to produce girdle ulcers is duplicated by the annular type of intestinal carcinoma because in both the circularly disposed intermuscular lymphatic plexus is involved. The chains of lymph nodes affected follow

the same anatomic course. Undermining of the mucosa in amebiasis suggests that type of carcinomatous growth in which the neoplasia starts at one point on the mucosa, spreads along the submucosal lymphatic plexus and reappears on the mucous membrane at some distal point.

Occasionally a patient with a liver nodule may live for years after resection. Metastases are most frequent from tumors of the rectum, sigmoid and proximal colon. The last is relatively poor in lymphatics, except at the cecum and sigmoid. In carcinoma of the transverse colon, omental metastases may occur. And, finally, carcinoma of the lower rectum (columnar, intermediate and cutaneous zones) may metastasize to the inguinal nodes.

Primary Tumors of Large Intestine

(Jan. 1, 1932 to May 1, 1934)

Carcinoma—32:

(A) Rectum—16:

Grade I	6	(age 32-65)
Grade II	8	(age 37-59)
Grade III	1	(age 50)
Grade IV	1	(age 40)

(B) Sigmoid—9:

Grade I	2	(age 61, 67)
Grade II	3	(age 45-74)
Grade III	2	(age 36, 44)
Grade IV	1	(age 36)
Ungraded	1	(age 57)

(C) Colon—7:

Cecum	2	Grade II	1	(age 56)	Mucinous.
		Grade II	1	(age 70)	Mucinous.
Hep. flex.	1	Grade II	1	(age 34)	
Trans.	1	Grade II	1	(age 54)	
Splenic	2	Grade I	1	(age 72)	
		Grade III	1	(age 26)	Death in 14 months.
Desc.	1	Grade III	1	(age 44)	Multicentric. No recurrence 18 months.

Other primary tumors—8:

(A) Multiple adenomata—3:

164 Autopsies: Multiple polyps in 3 of last 63 autopsies, one associated with diverticula of sigmoid, one with submucosal lipoma.

(B) Papilloma—1:

Anorectal.

(C) Tumors of appendix—4:

Cavernous hemangioma	1
Embryonal lipoblastoma	1
Carcinoid	1
Mucocele	1

THE ONE STAGE ABDOMINOPERINEAL OPERATION FOR
CARCINOMA OF THE RECTUM

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MANY considerations enter into the development of a surgical procedure aimed at the eradication of malignant disease of the rectum. First to be considered is the age and general condition of the patient; second, the extent of the process; next, the hospital facilities; and lastly, the ability and experience of the surgeon. As a general rule the surgeon should do the type of operation at which he is most adept and for which the facilities at hand are most adequate. However, if this rule were too strictly adhered to, it is quite evident that surgeons would adopt an attitude of *laissez faire* and would not extend themselves to accomplish improvements in technic. This is well exemplified when one reviews the history of the various surgical procedures applied to carcinoma of the rectum. In its evolution, of course, developments in anesthesia, bacteriology, physiology and chemistry, as well as improved hospital facilities, have further aided the surgeon in accomplishing a great deal for the unfortunate patient with cancer.

I shall discuss here only the one stage, combined abdominoperineal operation, whose chief protagonist is Miles, of London. The operation is admittedly severe, but it is not intrinsically difficult nor does its performance demand any exceptional ability. Miles was led to believe in the superiority of this procedure after a long experience with all types of operations and extensive study on the mode of extension and sites of recurrence following operation. Operations for cancer in any location necessitate thorough knowledge of the lymphatic system, and this is especially true so far as the rectum is concerned. Miles has given us a most lucid description of the lymph nodes in the rectal area.

Advocacy of any new procedure must be defended by thorough knowledge of fundamental principles, but space does not permit here any lengthy discussion of the relative merits of the one stage or two stage operation, except to point out that in the final analysis the only argument in favor of the two stage operation is the lower rate of operative mortality. It should be pointed out, however, that if a surgeon has 100 patients, he is really performing 200 operations and no surgeon is lucky enough to be immune from accidents beyond his control. Furthermore, mortality from the two stage operation is quoted only after the second stage is completed, so that if the patient dies from the colostomy operation, this is not reckoned in the statistics because he has never reached the second stage of the operation. The mortality of colostomy averages 4 to 5 per cent; if this number were added to the second stage where statistics of mortality often rightly belong if the two operations are to be compared on a fair basis, it is my feeling that the rate of mortality for the one stage and the two stage operations will be approximately equal.

An appropriate analogy, it seems to me, can be drawn from the field of thyroid surgery. Ten years ago, thyroidectomy for hyperthyroidism was a two, three or four stage procedure: the vessels were ligated first and the patient returned in two or three months for operation. Now with the use of Lugol's solution, the patient is prepared for operation in about ten days and the operation is done in one stage with an even lower mortality than previously.

So with the one stage operation, the largest individual factor is preoperative treatment which is so essential to its success, yet so little attention is paid to it. If the medical management is carried out thoroughly it will accomplish as much in preparation of a patient as will colostomy.

After the diagnosis of cancer of the rectum has been made, a thorough physical examination, of course, is essential. This is just as important as it is to have the physician do a digital examination of the rectum. A thorough search must be made for metastases and in a certain number of cases these can be seen (by the cachectic appearance of the patient) before they are felt. I believe that with the more widespread use of intravenous dyes, liver metastasis can be discovered in many instances, thus saving the patient from exploratory operation. If no contraindication to operation is found, the patient is hospitalized and preparation is begun.

Most of these patients have had more or less chronic obstruction for weeks or months and a drastic cathartic is contraindicated. I advise magnesium sulphate, one ounce of crystals in eight ounces of water, the patient to take one-half ounce of the mixture every half hour. This is repeated each day up to the day before operation. Magnesium salts are slightly irritating and cause fluidity of the stools by nonabsorption of water. They also stimulate peristalsis and make an ideal laxative for these patients. In addition, enemas are given each day. After three or four days of this routine the distended abdomen frequently becomes scaphoid. Lately in addition to the above measures, pitressin has been used with gratifying results. In order to make up the loss of water through the intestine the patient is encouraged to drink large amounts of orange juice, lemonade and water and, if necessary, hypodermoclysis is administered.

Because, for many weeks, the patient's appetite has been poor, it is likely that a considerable portion of the glycogen reserve in the liver has been exhausted. Hence 500 cc. of a 10 per cent solution of glucose are injected intravenously each day. The patient takes a high caloric, nonresidue diet. During his stay in the hospital the kidneys are investigated and estimation of urea clearance is made. Because of the age of many of these patients, there is an associated hypertrophy of the prostate, with obstruction and retention and consequent damage to the kidneys. Several patients in my series have had to have a punch operation of the prostate after recovery from the rectal resection. Overlooking a condition like this may readily prove disastrous, and if such a condition exists, the patient should have catheter drainage similar to the treatment preliminary to prostatectomy.

The impoverished myocardium usually improves with the increased glucose intake, but in case it does not, digitalis may be given for several days before the operation. During these preoperative days attention is given also to mouth hygiene. If the patient's hemoglobin or red blood cell count is low, a transfusion is given before, as well as after, operation; if the blood count is normal, the transfusion is withheld until after the operation in order to combat shock. Obviously the routine is entirely different from that in vogue not so many years ago, when the patient was brought into the hospital one night, given a dose of castor oil and operated upon the next morning.

After the patient has been well prepared for operation, anesthesia is the next important consideration. From my experience spinal anesthesia is to be preferred for its advantages far outweigh any disadvantages it may have. The relaxation and quiet abdomen are conducive to a more rapid performance of the operation and the fact that the anesthesia lasts only about an hour and a half is further stimulus to the surgeon to have things well planned and not to loiter, a habit too easily acquired if the patient is deeply anesthetized. There is not much choice in preparations used for spinal anesthesia today. In my experience, 150 to 200 mg. of Pitkin's solution has been used successfully in more than 3000 operations. Meticulous care is taken to observe the blood pressure, although many observers say it will always come back to normal even after marked depression. This may be true but the complications in the succeeding few days, it seems to me, have a direct relation to that insult at operation. The use of ephedrine has been boosted and condemned. Increasing the blood pressure as it does by increased cardiac output may be of doubtful value because the drop in blood pressure is caused by vasomotor paralysis. At present I resort to the use of epinephrine only when the patient's systolic blood pressure falls below 80. The argument that the action of epinephrine lasts only for a short time is not tenable, for the operation itself lasts only a short time. With a few injections of one-half cc. of epinephrine from time to time its effect will last until the anesthesia has disappeared.

As soon as the anesthetic has reached the level of the umbilicus, the patient is placed in the Trendelenburg position and prepared for operation. The various steps in the operation are simple and straightforward and are well within the capacity of any one possessed of average skill who knows what he wants to do and how to proceed. A long midline or left rectus incision is made and the liver is examined for metastatic involvement. Multiple nodules preclude operation; a small solitary nodule may not contraindicate operation for in such a case the patient may live two or three years and is much more comfortable if the primary growth is removed. The pelvis is then examined as to fixation or extension of the growth to the bladder or pelvic peritoneum.

If there is no contraindication to operation the first step is to incise the peritoneum on the lateral wall of the sigmoid at about the level of the pelvic brim. This fold is quite variable but it is usually necessary to incise it in

order to mobilize the sigmoid. Then the inferior mesenteric artery is identified; the Cameron light is very useful for this purpose except when there is considerable fat in the mesentery. In the latter type, the artery generally is situated in the mesentery about two inches below the bifurcation of the aorta. This is tied just below the point where the first sigmoid branch emerges: it is necessary to preserve this for the blood supply of the sigmoid. Isolation and ligation of this artery saves a lot of time which otherwise would be consumed in cutting and tying down vessels throughout the length of the mesentery. Then the peritoneum is incised on each side of the mesosigmoid down to the floor of the pelvis, anteriorly to the rectovesical pouch in the male or the pouch of Douglas in the female. The next step is to place the hand at the promontory of the sacrum and to separate all the fat from the hollow of the sacrum and push it forward. This dissection is carried down until the coccyx is felt. Attention is then directed to freeing the intestine anteriorly. A wide ribbon retractor is placed behind the bladder and with a long blunt scissors the dissection is carried down till the seminal vesicles are recognized. These are then pushed forward until the prostate can be felt, or, in the female patient, until the vagina is seen.

With the anterior and posterior dissection complete, traction on the bowel renders prominent the rectal stalks which support the rectum and these are divided as far laterally as possible; on the completeness of this dissection depends to a great extent the patient's curability and also the ease of posterior resection. The next step is dividing the bowel and the point of election depends on the redundancy or brevity of the sigmoid: if it is long, it is divided at a convenient point and brought out through the original abdominal incision for the permanent colostomy; if it is short it is brought out through a left McBurney incision. The bowel is divided by cautery between two crushing clamps and is tied with a heavy silk suture. Over each end is placed a piece of rubber dam which, again, is tied over the bowel. This saves time and prevents contamination by trying to invert the ends by purse string sutures. The distal loop is then placed in the pelvis and the pelvic floor is reconstructed. This is made from the flaps of peritoneum from the sides and floor of the pelvis and the posterosuperior surface of the bladder. If an opening remains it is repaired by placing an omental graft over the hiatus. This seldom is necessary. After closure of the incision with the colostomy either in the midline or left iliac region, the abdominal part of the operation is complete.

The patient is then placed on his abdomen in the Kraske position. A purse string suture is placed around the anus and an incision is made in the midline from midsacrum down to and encircling the anus. If the growth is low, a good portion of perianal skin must be taken. The skin flaps are dissected laterally until the gluteus maximus is seen. The coccyx is then disarticulated at the sacrococcygeal joint and the pelvic cavity containing the dissected colon is entered. The rectum is next dissected from above downward. The prostate or vaginal wall is in plain view and after the levator ani

are incised (as far laterally as possible) removal including the fat in the ischiorectal space, may be quickly accomplished.

There remains a large cavity surrounded only by the bladder in front and the bony wall of the pelvis. A large rubber square is placed into the cavity and this is packed with gauze to stop the oozing and to help support the new pelvic floor. The incision is then closed except for a distance of two inches, where the drain is situated. The gauze is partly removed on the second, third or fourth day and the cavity is irrigated daily with solutions of sodium chloride or boric acid or a 1 to 8000 solution of bichloride of mercury. After this the patient is put to bed and a blood transfusion of 500 cc. of blood is administered.

Postoperative treatment then is symptomatic. The colostomy is opened on the second, third or fourth day, depending on the degree of abdominal distension. The patient receives a full diet as soon as the colostomy is opened.

If there are no contraindications, the patient is encouraged to get out of bed on about the twelfth to fourteenth day after operation. This helps to make the new pelvic floor sag, thereby hastening the filling of the large cavity. Before the patient returns home, he is instructed regarding irrigation of the colostomy and other general care.

I believe that properly planned and executed, this operation offers the best hope of cure of cancer of the rectum. The operative mortality rate in 135 cases is 11 per cent.

The percentage of patients with five years' immunity from carcinoma is 52; with three years' immunity, 62 per cent; and 67 per cent of this group have been well for less than three years.

TWO STAGE OPERATION FOR RECTAL CANCER

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RADICAL surgery of rectal cancer has now attained such a degree of technical perfection that it would seem that slight, if any, advance in operative technic can be looked for.

Contributing factors have been improvement in the preoperative survey and preparation of the patient, postoperative care, and above all the selection of the type of operation best suited to the individual case.

The operative maneuvers have become clearly defined and standardized into the following types:

- (1) One stage abdominoperineal operation.
- (2) Two stage abdominoperineal operation.
- (3) Two stage perineal excision.

- (4) Posterior resection.
- (5) Perineal amputation.

This classification implies that the surgeon undertaking this type of surgery should be familiar with, and skilled in, the performance of each of these operations as indicated.

The one stage abdominoperineal operation, as perfected by Miles, with permanent terminal sigmoidostomy and removal of the entire segment distal to the stoma, is the ideal from the standpoint of wide eradication of the disease and prevention of recurrence. Indeed, this wide excision is the only practical procedure when the rectosigmoid is involved, as it is in approximately 60 per cent of cases. Experience has shown, however, that the same radical removal can be accomplished with less risk by dividing the operation into two stages, namely, a preliminary colostomy to be followed in a fortnight or longer by the excision.

Pioneers in the development of the two stage operation are W. J. Mayo (1912) who did a loop colostomy, ligated the blood supply to the rectum and closed the ends of the pelvic colon sectioned distal to the colostomy, burying the aboral, devitalized segment beneath the closed peritoneum, to be removed extraperitoneally at the second stage. In 1915, Daniel Fiske Jones proposed a loop colostomy with central ligation of the sigmoid vessels, thus preserving the vascular arches from the left colic artery and blood supply to the distal segment; freeing the rectum on all sides and suture of the dissected pelvic peritoneum to the sigmoid above the point of central ligation of its vessels and above the tumor. The loop colostomy facilitates cleansing of the distal segment by irrigations before the second stage which is an extraperitoneal procedure. Inversion of the proximal end of the bowel at the second stage, however, leaves an undesirable blind pouch distal to the colostomy. In 1932, Jones reported his operability as 60 per cent, operative mortality, 20.7 per cent; operated patients alive at three years, 73 per cent; and at five years, fifty per cent, or 26.2 per cent of total cases seen.

Coffey, in 1914, published a procedure the chief object of which was to protect the peritoneum from infection. It accomplishes this aim very effectively. In the first, which is the major stage, the sigmoid is divided and an end colostomy is established, the distal vessels are severed, the distal pelvic colon and the rectum are dissected and the peritoneum closed in such manner that the lower portion of the peritoneum of the abdominal wound is united to the margins of the pelvic peritoneum dissected from the pelvic colon. The distal segment of colon is inverted through the rectum; in women, through the posterior vaginal fornix, beneath the closed peritoneum. Large cigarette drains, inserted to the bottom of the pelvis, emerge through the lower angle of the abdominal wound.

At the second stage, ten days later, the distal segment and rectum are removed from below by wide dissection. Due to the considerable dissection and suturing required, the first stage is comparatively long while the second

stage is short. This operation, like that of Mayo, has the disadvantage of leaving, between stages, devitalized bowel with poor drainage in the freshly denuded pelvis. Dudley Smith modified Coffey's technic of the first stage by complete closure of the abdominal wound and inserting rubber dam drains through an incision lateral to the coccyx.

At the twenty-third annual Clinical Congress of the American College of Surgeons, Coffey reported that a total of 239 cases of carcinoma of the rectum and rectosigmoid had been admitted to his clinic. Radical removal was done in 31 cases of rectosigmoid growth, hospital mortality seven (22.5 per cent); and in 82 cases of carcinoma of the rectum by his "inversion technic" hospital mortality six (7.3 per cent). Fifty-one patients were traced, of whom 23 died before the end of five years. Of the 28 who survived over five years, 13 died, two only of recurrence; and 15 were alive without known recurrence from 5½ to 15 years after operation.

My own experience with Coffey's method in a single case was no infection of the peritoneal cavity, a stormy convalescence, but a very satisfactory result.

Mr. A. H., aged 52 years, had a large carcinoma beginning three and one-half inches above the anus on the anterior rectal wall and involving the rectosigmoid. The first stage was performed on June 8, 1925. Colostomy was established and the tumor bearing segment removed through the abdomen. Twelve days later the second stage perineal excision was carried out. Now, nearly nine years later, the patient is in excellent health. His colostomy functions well, his weight is the highest it has ever been and he follows his usual occupation without discomfort.

The next steps in the evolution of the two stage operation and the nearest approach to the one stage ideal procedure were advanced by Rankin and Lahey. Both procedures have the virtue of preserving the blood supply of the distal segment until the second stage excision.

Rankin, in 1929, advocated as the first stage an end colostomy, dropping back into the peritoneal cavity the closed distal end of the divided sigmoid, and preserving intact the blood supply of the distal segment. As a consequence, the second stage may be deferred as long as seems beneficial for the improvement of the patient's condition, rectal irrigations being given meanwhile. At the second stage the rectum is dissected from below, encased in a rubber glove, and the entire rectum and distal sigmoid removed through the abdomen. In 1934 he reports that in a series of 85 cases there were eight operative deaths, a mortality of 9.5 per cent. Of 300 cases of carcinoma of rectum and rectosigmoid operated upon in a total group having an operability of 50 to 60 per cent, 114 or 38 per cent, were alive and free from recurrence at the end of five years.

In 1930, Lahey modified the first stage of Rankin's method by fixing the distal segment of the divided sigmoid colon into the lower angle of the abdominal wound, thus affording an easy and efficient way of irrigating the distal segment. A practical difficulty may be experienced in obese subjects in bringing the distal end of the sigmoid to the skin surface and in retain-

ing it there when the mesosigmoid is short. A minor disadvantage in the second stage is that the infective stoma must be closed just before opening the peritoneal cavity, dissection of the pelvic colon and rectum, and removal of the entire distal segment from below. Lahey (1934) reports that he and his associates have employed this method in 29 consecutive cases without an operative death.

The advantages of the two stage over the one stage abdominoperineal procedure are its greater safety and its applicability to cases in which the one stage operation would be too great a hazard. Between stages, function of the colon is established, a notable degree of rehabilitation of the patient is accomplished, nutrition improved and toxemia reduced. Moreover, irrigation of the distal loop cleanses it of feces, renders the ulcerated carcinoma comparatively free from infection and, as a consequence of the reduction of inflammation, the tumor bearing segment is frequently shrunken and so more easily and safely removed at the second stage.

The two stage perineal excision for tumors of the rectum proper justly merits the popularity accorded it, especially by British surgeons. At the first stage the abdomen is explored and a loop colostomy established. About two weeks later, during which the distal segment has been irrigated and the general condition of the patient improved, the distal segment is removed through the perineum at a safe distance above the tumor, and the proximal end inverted by a double row of sutures.

Miles abandoned this procedure after recurrences in 94.4 per cent of the patients in which he had used it. Nevertheless, Gabriel's statistics of 370 cases of posterior resection by the surgical staff at St. Mark's Hospital are impressive. Of 189 cases operated upon (1910-1926), 55 or 36.4 per cent survived five years without recurrence. Of 91 cases operated upon (1910-1921), 20 were cured on a ten year basis, *i. e.*, 30 per cent. In both series the "untraced" and those "dead from other causes" are excluded in estimating the results.

The chief advantages of the two stage perineal excision are its safety in poor risks, in anemic and weak individuals, in very obese subjects and in patients having cardiorenal complications, conditions which bar the more hazardous one stage procedure. Where applicable, the two stage posterior resection is the safest operation in the hands of the average surgeon.

Posterior resection implies dissection of the lower pelvic colon and rectum through the abdomen; posterior removal of the coccyx, possibly with a portion of the lower sacrum, delivery of the tumor bearing segment of bowel through the wound, its division above and below the growth and circular suture of the ends. As an alternative, the upper segment is drawn through the previously denuded anal canal after the method of Hochenegg. Posterior resection involves an exacting and difficult technic and is employed by very few surgeons. Its complications are infection and later stricture or fistula at the site of the circular enterorrhaphy. Recurrences are frequent.

Perineal resection (amputation) of the rectum without colostomy should be reserved for neoplastic involvement of the anal canal and lower rectum in which the finger, introduced per anum, reaches the upper margin of the growth. If the roentgen ray shows a freely movable sigmoid colon of average length, as much as six to eight inches of bowel can be brought down and amputated, and a new anal outlet established at the normal site. This is an excellent operation in obese patients and in the aged, and in females especially its accomplishment is technically easy.

My personal experience with perineal resection has been quite extensive and in general very satisfactory both as to immediate and late results, including control of the feces. Several patients have lived in comfort and without recurrence over five years, one more than ten years after operation.

GOLD RADON SEEDS IN RECTAL CANCER

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SELECTION of the most appropriate treatment for a given case of rectal cancer may be an easy or difficult problem. There are many variable factors to be considered at the time the disease is recognized. Analysis of these factors varies widely. They may suggest a hopeless condition or possibility of a clinical cure. Experience has proven that best results are obtained when each case of rectal cancer is considered a separate problem and treated in accordance with clinical and pathologic factors.

Treatment of cancer is a surgical problem. Different methods of surgical technic are advantageous. Radium and roentgen ray should be considered additional surgical equipment. In our clinic we employ the one and two stage abdominal perineal operations; the perineal extirpation usually preceded by a colostomy and radiation therapy. Radiation therapy is used alone, as a palliative measure, and in selected cases to promote clinical cures. The physical agents are also at times combined with colostomy and radical surgical removal.

Implantation of gold filtered radon seeds into the tumor mass constitutes one form of interstitial irradiation. The method may be used separately, as the only form of radiation therapy, but usually it is combined with preliminary external irradiation. Radon seeds are a means of delivering sub-lethal and lethal dosages of radon to malignant cells. The field of irradiation is largely limited to the tumor mass, there being only a moderate effect upon the rectal mucosa and surrounding tissues, provided seeds are not inserted beyond malignant areas. By varying the number and strength of seeds, large, as well as small, tumors may be influenced.

Gold radon seeds consist of radon encapsuled in a small gold tube. The seeds are four to five Mm. long, 0.75 Mm. in diameter with a three-tenths thickness of gold. The glass filter of the radon seed was replaced by gold in

1925. The strength of seeds varies from one-half to three millicuries each. They are implanted into the tumor mass by trochar needles and left in place. A number come to the surface and are discharged, while others remain *in situ* for years.

Technic of application is of utmost importance. It is upon this factor together with selection of total dosage and strength of individual seeds, that ultimate results largely depend. It is not, as many of the unexperienced believe, a simple procedure to adequately irradiate a cancer situated in the rectum. There is much more to this operation than merely inserting haphazardly a number of radon seeds. In order that the disease may be eradicated sufficient dosage must be delivered to every malignant cell to cause devitalization. At the same time surrounding normal tissue should be spared unnecessary damage. Adequate interstitial irradiation is facilitated by careful estimation of the size, shape, thickness, degree of radiosensitivity, *etc.*, of the tumor. Such factors permit calculation of the required total dosage and the selection of the individual strength and distribution of the seeds. The operation of implantation ought to receive equal consideration to that afforded surgical extirpation of the rectum. When the case is a favorable one, the objective is the same in both instances, namely, a clinical cure of the disease.

Patients are selected for radiation therapy after careful examination and appraisal of the clinical and pathologic factors. These factors are such as to separate patients into favorable and unfavorable groups. Usually those selected for radiation therapy, whether they be favorable or unfavorable, receive preliminary external irradiation. Following completion of the external irradiation patients are admitted to hospital for interstitial implantation. The rectum is cleansed by irrigation or castor oil. Insertion of seeds is carried out in a suitably equipped operating or treatment room. Anesthesia is required in only a small percentage of cases. In many instances, it is an advantage not to have the patient under complete narcosis. All seeds are threaded into trochar needles and made available for use before the operation is commenced. This shortens the length of time required for the patient to remain quiet in one position. Patients are placed in the position which on previous examination was found to give best view and greatest accessibility to the tumor. The knee chest and dorsal are the most frequently employed, but occasionally the lateral position offers additional advantages. The implantation is made in most instances by direct vision through an electrically lighted proctoscope. Bleeding is seldom troublesome. The operative field is kept clean when necessary by the aid of a suction apparatus.

The proctoscope is first passed beyond the tumor and is then withdrawn until the upper limits of the cancer come into view. This upper area is implanted with seeds. They are placed three-quarters to one cm. apart depending upon their strength. The proctoscope is then withdrawn for about one cm. and another row of seeds implanted. This procedure is repeated until the whole tumor has been implanted. Thickness of the malignant area largely determines the strength of the seeds. When possible, seeds of sufficient

strength to affect the whole thickness are employed. Occasionally in very thick tumors a double layer of seeds is necessary. Tumors of the lower rectum may be treated with the finger placed within the rectum to guide the distribution of seeds. The needles may be inserted by way of the anal canal, perineum, and in females through the posterior vaginal wall. Radiation therapy is a selective method of treatment. It may be used alone or in combination with surgery. An attempt will be made to show the value and advantage of implanting gold seeds in certain types of rectal cancer.

Our greatest experience in radiation therapy has been with the inoperable group of cases. External therapy is advantageous to all advanced cases that remain ambulatory and are able to take treatment without hospitalization. Interstitial radiation is suitable for only about 50 per cent of the advanced cases, namely, those in better physical condition in which a higher degree of palliation is possible. The object of palliative treatment is to hold the growth in check, decreasing the symptoms and increasing the patient's general condition. When possible these results should be obtained without an untoward reaction. The group which is considered unsuitable for interstitial irradiation is comprised of patients usually in poor physical condition, and those with very large and deeply infected tumors. Implantation of gold seeds even in small dosages in a highly infected tumor is often followed by a reaction from which the patient may never completely recover. Over-radiation in these unsuitable cases may result in a slight prolongation of life, but the discomfort produced and the increased symptoms which may follow the implantation for a considerable period of time seldom compensate for the slight extension of life. Much of the adverse opinion of radiation therapy in rectal cancer has been created by intensive treatment of unsuitable cases.

There are a fair number of inoperable cases that are benefited by interstitial irradiation. The first class to be considered are those in which only small dosages are required. These patients are in fair physical condition. Their tumor is large, but the degree of infection is comparatively mild. Radon seeds are used under these circumstances to supplement the sublethal dosage supplied by external applications. The strength of seed varies from .75 to 1.50 millicuries, and the total dosage inserted at one time is seldom more than 20 millicuries. These small applications are often repeated as the initial dosage is not sufficient to influence the whole lesion. By repeating both the external and interstitial applications it is not unusual to carry these patients along for an interval of one or two years. Eventually, however, the tumor becomes badly infected and further interstitial irradiation is contraindicated.

The third class of inoperable cases consists of patients in fair physical condition who are able to withstand a moderate radium reaction, the result of which should be either a complete disappearance of the activity of the tumor, or a marked lessening of the symptoms over a much longer interval. The local lesion is large and usually a Grade I or Grade II malignancy. Radical surgery or attempt at removal in this type of case offers very little palliation. Too frequently radical surgery results in an operable fatality or early

recurrence which is harder to control than the original disease. If this group is untreated, or only a colostomy constructed, the period of comfort is comparatively short. Radon seeds appear to offer the greatest benefit of any of the present day methods of treatment. Seeds employed under these circumstances are of two or three millicuries each with a total dosage of 40 to 75 millicuries. Large amounts of radon are required because of the size of the tumor. An effort is being made to devitalize completely all the malignant cells of an inoperable case. There may be considerable postradiation reaction when this large dosage is employed, that may extend for several weeks. If cases are carefully selected one need not withhold treatment because of this reaction; for the ultimate result will well compensate for the period of discomfort. Colostomy is often required to relieve the obstruction produced by these large tumors. Moreover, the artificial opening greatly facilitates the implantation of the seeds, as it is employed as a means of approach to the upper limits of the tumor; the lower limits being treated by passing the proctoscope through the anal canal and lower rectum in the usual manner.

Gold seeds also have a place in the treatment of the operable rectal cancer group. We are all familiar with the frequency of early recurrences due to incomplete removal in the so-called operable case. In an attempt to improve this factor we have employed preoperative interstitial irradiation seven to 14 days prior to operation. The results in this advanced operable group warrant the continuation of this method as they have been much better than could be expected from surgery alone. The technic of preoperative therapy differs somewhat from that already described. Seeds from two to three millicuries are implanted into the outlying or infiltrating areas, the cancer cells serving as a holder for the radium. The total dosage delivered to these areas is in excess of that required for devitalization. In other words, an overdose is employed. The part of the tumor contained within the rectum proper need not be treated, as it is easily removed at the time of operation. The object in using radon in this manner is to devitalize only the outlying malignant cells, particularly those which may be left after a radical dissection. The short time between the application of radon and the operation does not permit the occurrence of any severe reaction even though massive dosage is employed. Moreover, the operation is not made any more difficult by preoperative irradiation unless an interval greater than a fortnight is allowed to elapse between procedures.

It is difficult to say what the additional percentage of clinical cures is afforded by the combined use of radiation therapy and surgery. However, clinical observation leads us to believe that a number of our cases operated upon owe their present satisfactory condition to this combined form of therapy.

There is a large field for postoperative radiation therapy in rectal cancer. It is fair to estimate that about one-half of the patients subjected to radical surgery die of cancer. Many deaths are associated with local recurrence.

If the local recurrence is accessible for interstitial irradiation and recognized early, a great deal of palliation, together with extension of life, can be provided these unfortunates. Gold seeds may be implanted at the time of operation if the surgeon considers that all malignant tissue has not been removed. If radon seeds are not available at this time they may be inserted during the convalescence as soon as the condition of the wound will permit. When the recurrence is discovered at a later date treatment should be given at once. Early recognition of a recurrence is almost as important as the early recognition of the primary lesion.

The previously considered indications for the use of gold seeds have all been in advanced or borderline operable cases. Gold seeds may be employed under more favorable circumstances, namely, in purely operable cases. By operable is meant a movable tumor of medium size in which the disease appears limited to the submucous and muscular coats without further involvement than the adjacent lymphatic nodes.

Operable cases for radiation therapy should be carefully selected. All operable cases should not be treated by this method. Tumors selected for this form of therapy must be so situated that seeds may be distributed accurately throughout the mass. In most instances they are located in the lower or mid rectum below the reflexion of the peritoneum. The general condition of the patient is such as to withstand a moderate radium reaction. The strain of such reaction is much less than that following radical surgery; therefore this may be the method of choice for operable tumors in patients unable to withstand a suitable operation. The majority of operable cases that have been treated by gold seeds have been in patients in rather poor physical condition, or in those who absolutely refused any form of surgery. Our results have led us to believe that the method may be extended to include a larger selected group. It is very gratifying when one is able to obtain a clinical cure of long standing and have the patient retain a normal and practically normal functioning terminal intestinal tract. Strong possibilities of clinical cures of operable tumors in good surgical risks should not be overlooked in our enthusiasm to use radiation therapy. Unless the tumor lends itself well to this method surgery should be the method of choice. With the proper setting in a disease that is localized, one need not hesitate to use this method, for we are employing an agent which, if adequately placed throughout the tumor mass, is capable of destroying all the cancer cells.

There is another type of case in which gold seeds are of great value; this is the precancerous or very early cancerous lesion. There may be a difference of opinion as to the malignant nature of such tumors. One pathologist may report a nonmalignant polyp, while another will consider the lesion an adenocarcinoma. Many of these early lesions are in elderly people in whom radical surgical procedure cannot be lightly considered. It has been our practice in recent years to remove these polyps or tumors with an electric snare and submit the whole removed mass for histologic study. The report of malignancy at the base places the lesion in a dangerous category. If there is any induration

of the mucosa after removal, this area is irradiated with gold seeds. The localization and the small area involved lends itself well to adequate interstitial irradiation by this method alone.

It is difficult to summarize the results from gold filtered radon seeds, as in most instances this form of therapy has been combined with external irradiation. A review of our active files shows 24 patients who were treated prior to 1933 to be clinically free of rectal cancer. In order to give a cross-section of our results, patients treated between 1926 and 1930, inclusive, have been reviewed. During this five-year period we were able to follow 238 patients treated by radiation therapy or radiation therapy and colostomy. Two hundred and thirteen of this number were advanced and suitable for only a moderate or minimal degree of palliation. Eighteen or about 8.5 per cent did not appear to be benefited by treatment. Forty or about 19 per cent received minimal palliation. A much greater degree of palliation was provided to the remaining 155 patients. The length of life in this advanced group was as follows: 183 lived over six months; 112 over 12 months; 65 over 18 months; 20 over 30 months; nine over three years; and one for four and two-third years. During this period there were 25 cases selected for heavy radiation therapy, the object being a clinical cure or a high degree of palliation. Fifteen of this number were considered operable, and ten inoperable. An artificial anus was constructed in 12 instances, while 13 patients were treated without any form of surgery. Thirteen of the 25 patients are now alive and clinically free of local disease. Of the 12 patients dead, three died of inter-current conditions; and one from unknown causes. Of those dying unmistakably of their disease, one lived for 15 months; one for two years; three for three years; two for four and one-half years; and one for over five years. The results in this latter group compare favorably with those obtained from radical surgery alone. However, ten of these patients were considered inoperable, and many of the others were poor operative risks.

EXTERNAL IRRADIATION IN RECTAL CANCER

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EXTERNAL irradiation is an important procedure in the treatment of rectal carcinoma. This applies to all cases, and in all stages, although in a varying degree, according to the type of lesion, and also according to the other procedures to be followed in the care of the disease. Carcinoma of the rectum is rarely treated at this hospital by surgery alone, and is seldom subjected to external irradiation only, except for palliation in advanced stages. The combination of irradiation and surgery is usually required for the proper care of these patients. This discussion will be limited to external irradiation, simply mentioning the other procedures with which it may be combined.

External irradiation is used in the treatment of carcinoma of the rectum

in one of the following methods: (1) as an adjunct to surgery; (2) as a major procedure, surgery playing the minor part; (3) as the only procedure to be followed.

Surgery and External Irradiation.—In the operable cases external irradiation is usually the first step in the treatment, the exception being in that type of case which is in need of immediate colostomy. The reasons for irradiation preliminary to surgery are several. It is often our experience that even an operable case shows considerable toxicity with a consequent poor general condition of the patient. The external irradiation effects a general improvement and a sense of well being, as is manifested by increased appetite, gain in weight, and improved appearance. This type of therapy also causes a diminution of the infection, in the frequency of bowel movement, amount of mucus, and invariably arrests bleeding. These benefits also add to the general improvement of the patient. In no other type of neoplastic disease is there so prompt and decided improvement in the health of the patient. This improvement is often noted by the patient within a few days after the beginning of treatment. Another and important effect of this type of treatment is a decrease in the size of the tumor, which should make the surgery less difficult. This diminution in the size of the tumor occurs after the subsidence of the symptoms.

The tumor is exposed to irradiation through six to seven portals on the usual high voltage therapy unit, using 200 K.V., $\frac{1}{2}$ Mm. cu. filtration at 70 cm. T.S.D. The six portal cycle consists of two anterior, two posterior and two lateral portals. The seventh portal is a perineal field when the tumor is in the lower rectum or anal region. The dose is usually 700 to 800 *r.* over each portal, or 500 *r.* with repetition. The dose is so calibrated that there will be no severe skin damage to delay the operation which is done two or three weeks following the last exposure to roentgen ray.

External Irradiation and Surgery.—In the inoperable group, surgery is indicated in obstructive lesions, the care of the tumor itself being delegated to external irradiation. This inoperable group may not be necessarily unfavorable. Because of the radiosensitivity of the tumor, it is possible to effect a complete regression by heavy external and interstitial irradiation. In a few instances in which the growth is rather extensive, but nevertheless localized to the pelvis, the greater dependence is put on the external irradiation following which the mass is excised as widely as possible, with implantation of radon in the residual tumor. The surgery here is of minor importance in the care of the lesion, the greatest dependence being put on the external irradiation, interstitial being used to complete the treatment.

With the same roentgen ray factors as in the previous group, the tumor is exposed through six or seven portals, depending on the location of the tumor. In this group we employ the divided dose method, using successive ports, thereby subjecting the tumor to irradiation daily, but exposing the skin to irradiation only the sixth or seventh day. The skin over each area is thereby allowed to recuperate over a period of six or seven days, while the tumor itself is being irradiated each day. The dosage is 500 *r.* per day to successive

ports until a total of 1,500 *r.* or 2,000 *r.* is given over each port. If the patient is unable to withstand this treatment, 400 *r.* are given daily to successive ports until a total of 1,600 *r.* is given to each. In the former instance, 18 to 21 days are utilized in delivering the dosage, while in the latter 24 to 28 days are needed.

This method of irradiation is especially applicable to those cases which are radiosensitive and offer a good prognosis. In nearly all instances it is necessary to implant the remaining mass with gold tubes of radon. In the more radiosensitive type of rectal carcinoma, the reduction of the mass is marked, and very little interstitial radon is required. This is a decided advantage, because this latter type of irradiation often produces a more or less severe systematic reaction, probably due to breakdown and infection of the tumor. Moreover, the pain following large doses of radon may be severe. Reduction of the size of the tumor permits a lesser dosage which is at the same time adequate. Expressing this in another way, as tumors are larger, we might say arithmetically, the interstitial dosage increases in almost geometric progression. It should be readily seen that this heavy external irradiation, with a marked reduction in the size of the tumor, offers a very decided advantage in the treatment of rectal cancer.

External Irradiation Alone.—At this hospital most of the cases applying for treatment are beyond that stage at which a cure can be anticipated because of the extent of the disease. Before institution of treatment, an estimate is made of the amount of palliation to be attained. In the more hopeful cases, the pelvis is irradiated in a manner similar to that group in which the greatest dependence is put on external irradiation and the residual carcinoma is cared for by gold seeds. Most of these patients show a marked improvement in their general condition and are able to carry on their regular routine for an indefinite period of time.

In the more advanced cases, the pelvis is irradiated with more intensive doses, thereby permitting a total amount of irradiation in lesser time and in fewer trips to the hospital. Practically all these patients show a marked general improvement in the general condition, though the degree of improvement depends on the sensitivity of the tumor, and also on the ability of the patient to withstand the treatment. It is readily understood that a debilitated patient, who must abbreviate his treatment time to conserve his strength which is taxed to the limit by frequent trips to the hospital, cannot be benefited to the same extent, as can the patient taking the full course of therapy.

It cannot be shown by statistics the amount of palliation that these patients receive, but it is obvious to anyone observing them that the symptoms are relieved, health improved, and life prolonged. The local effect of this palliative therapy may be noted by the lessened infection, decrease in size of the ulcerated area, and occasionally a fixed tumor may be found to have become more or less movable. With the general improvement, further irradiation may be given up to skin tolerance.

Since this is a discussion of external irradiation it might be of interest

to discuss briefly two of the very rare cases in which this type of irradiation caused the complete disappearance of the primary lesion. Quite obviously, these cases were of the very malignant type and therefore totally unsuitable for surgery. Even though the patients were not ultimately cured they received striking palliation. One man only 26 years old, with a bulky rectal tumor, received external roentgen ray to the anterior and posterior pelvis. The apparent complete regression lasted nearly four years, at which time there was reactivity of the disease, which was again controlled by radium through each lateral port of the pelvis. There was again some regression, but the patient died shortly afterward of liver metastases. The second patient was first seen in 1927 with a tumor which was 3.5 cm. in diameter, which did not occlude the bowel, but was almost completely fixed to the surrounding tissue. It was situated 8 cm. from the anal margin. He received two cycles of roentgen ray about the pelvis by the single dose method followed by radium element pack anteriorly and posteriorly. This man has remained free of any local evidence of disease. A few months ago he developed pulmonary metastases. Although these are not brilliant results, they are at least palliative results that could hardly be expected by any other method of treatment.

In this discussion roentgen radiation only has been mentioned as the method of external irradiation. This is so because this type of radiation is used in many clinics, whereas a pack with a sufficient quantity of radium for external irradiation is available in few institutions. It is my firm belief that radium is much more efficacious than roentgen ray for external irradiation; there is more marked regression of the tumor, and this regression should be more lasting. This latter statement may not be susceptible of proof, but it is a clinical impression gained by many observations.

The objection to external radium therapy is the time interval to deliver adequate dosage. In the operable cases, the operative procedure is too long delayed. In the group for palliative treatment, it is a great effort for a debilitated patient to make the required number of visits to the hospital. Hospitalization for the duration of the treatments is seldom possible. However, those cases with a favorable prognosis, and also those suitable for good palliation, should be treated by external radium therapy.

ANAL ANATOMY WITH REFERENCE TO THE WHITE LINE OF HILTON AND THE PECTEN OF STROUD

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IN 1863, Hilton⁴ described a structure which bears his name as "A white line, which in the living subject any surgeon can recognize, shows the junction of the skin and the mucous membrane. That white line corresponds exactly to the lineal interval between the external and internal sphincter muscle. It is an important landmark, exact and truthful, so that it can be relied upon."

In 1896, the anatomist Stroud⁷ described a region which he found in the anus of several species of animals and in man *post-mortem*, and which he designated as the "pecten." According to his description, the pecten is distinguished by the following features:

- (1) It is bounded caudad (ectad) by the line of junction of the ectal and ental sphincters (Hilton's white line) and cephalad by the linea dentata.
- (2) It has a smooth, even texture and a glossy, shining appearance. The color is intermediate between those of mucosa and skin.
- (3) It has few or no openings of sweat-glands.
- (4) It is moderately vascular.
- (5) It is covered by a stratified epithelium which is richly supplied with nerve endings.

Miles⁶ emphasized the significance of the pecten by describing the heavy deposit of fibrous tissue underlying it as the pathological result of inflammation, "pectenosis." In order to cure fissure-in-ano, it was necessary to cut this stenosing ring of fibrous tissue, or perform the operation of "pectenotomy." Abel¹ has recently reiterated the teachings of Miles.

Anderson,² after studying sections taken through one side of the anal canal, has recently stated: "(1) Hilton's line, as described by him, may be either the anorectal junction, or the pale ring in the anal canal, depending on interpretation. (2) Neither of these lines represents the depression between the external and internal sphincter muscles to any constant degree. (3) There is no constant relation between the anorectal junction and the underlying muscles."

From Martin's⁵ writings, the following has been extracted: "The 'white line' of Hilton, just below the anorectal line, representing the condensation of tissue between the two sphincters, is much less elastic than any other portion of the anal canal. Some of the fibres from the mid-portion of the levator ani muscles find their insertion at this point."

It appears from the above excerpts that a certain amount of confusion

exists in the minds of anatomists and proctologists as to the two structures, Hilton's white line, and the pecten of Stroud. The cause of the confusion appears to be a lack of appreciation that Hilton's white line is a structure found in the living, whereas the pecten has been described from fixed and post-mortem specimens. Reflection on the part of the reader will immediately convince him that it is impossible for one to duplicate at post-mortem or by section conditions as they exist in life, since death and anæsthesia both cause relaxation of the sphincter muscles and distortion of their relationship to neighboring structures.

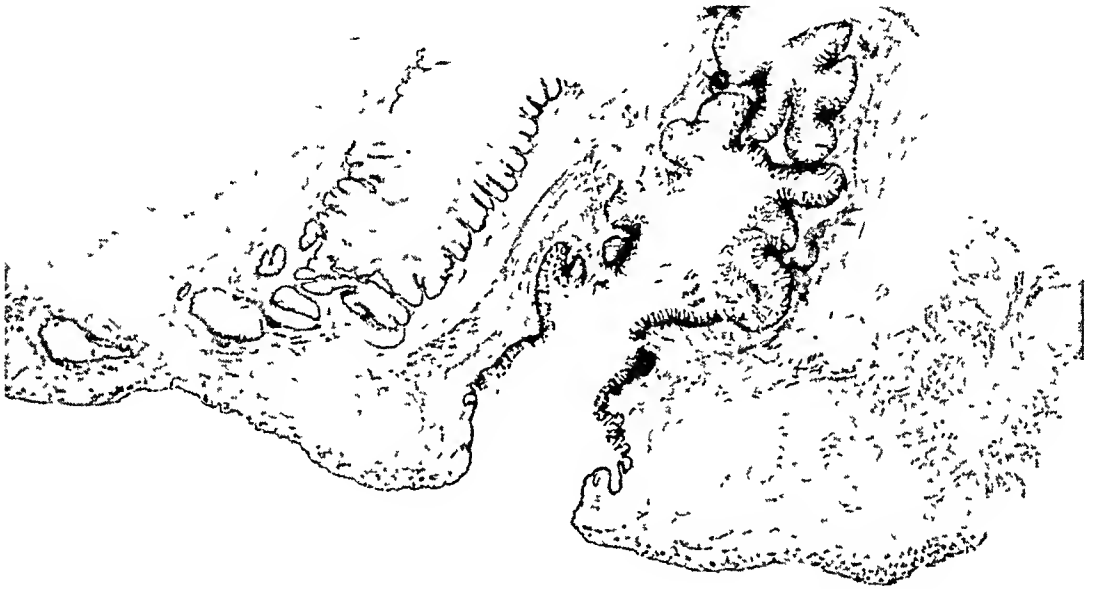


FIG. 1.—Sagittal section through perineum of a six months' premature foetus. Eosin, hematoxylin stain.

A sagittal section through the entire perineal region (Fig. 1) post-mortem, shows the anus gaping, and the external sphincter, which in life is found caudal to the internal sphincter, lying lateral to it. This distortion does not become evident unless the section embraces both sides of the anal canal. The section further depicts three distinct types of epithelium: *i.e.*, the skin with its hair follicles and glands terminating where the uncornified epithelium begins, and the latter terminating at the anorectal or pectinate line where the mucous membrane begins. In the foetus, these lines of division are sharply demarcated, but in the adult the levels of the lines of division may be greatly warped by existing or previously existing pathology. The uncornified skin is firmly fixed by and to subjacent fibrous tissue which begins at the termination of the muscularis mucosæ (Fig. 2 and Fig. 4) of the rectum and which is contributed toward largely by the fibrous terminations of the external longitudinal muscular coat of the bowel. The external longitudinal bowel terminations also penetrate the levator ani muscle, and some fibres pass between the various layers of the external anal sphincter to end in the cornified skin surrounding the anal opening. (Fig. 3.) Other fibres fix the internal anal sphincter by passing into it and through it in loops

and slings. The dense fibrous area beneath the uncornified epithelium of the anus surrounds the anus except at such points where the blood-vessels penetrate it to supply the sphincter region. This point was emphasized by the writer in a previous work.

The contention of Miles that the fibrous tissue deposition beneath the uncornified epithelium of the anus is the result of inflammation seems difficult to comprehend when one sees in the accompanying illustrations quite a deposition of fibrous tissue even before birth. One can readily appreciate, too, how at operation, if one were to cut the internal sphincter muscle, one might secure only bits of fibrous tissue for biopsy from the wound, since the spastic

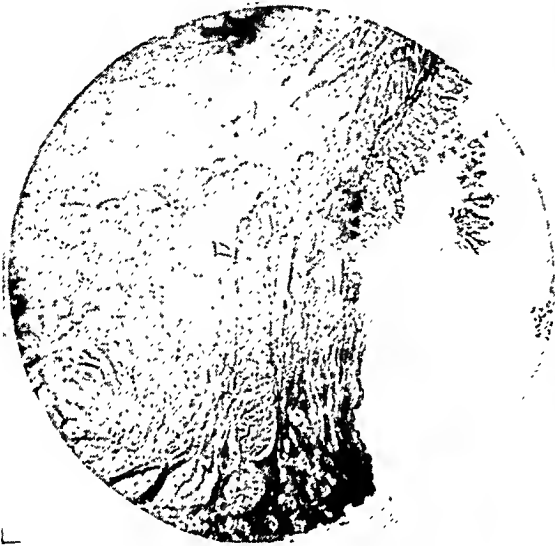


FIG. 2.—Section through one side of anal region in premature foetus showing dense deposition of fibrous tissue beneath uncornified epithelial layer beginning at the termination of the muscularis mucosae. Van Gieson stain.



FIG. 3.—Section through one side of anal region in a premature foetus showing disposition of the fibrous terminations of the external longitudinal muscle coat of the bowel. Van Gieson stain.

internal sphincter readily retracts when cut, leaving the abundance of fibrous tissue normally present readily available. On the other hand, in the narrowed ani of persons who have kept their stools liquid by the prolonged taking of saline cathartics, and in strictures due to other causes, there is undoubtedly a contracture accompanied by an increase in the fibrous tissue beneath the pecten.

The white line of Hilton, seen when the anal orifice is retracted, is in reality the pecten. It is the region of the uncornified epithelium and is essentially poorly vascularized. When the anus is retracted against the pull of the internal sphincter muscle, one can imagine how the blood might be forced out of this area and the appearance of a white line be produced. This white line appears to lie between the two sphincters, because it cannot be drawn down beyond the external sphincter muscle. In the living, when both sphincter muscles are contracted, it probably does lie pretty well between the two muscles, but when relaxed, as shown in the accompanying illustrations, the area ascends farther into the anal canal.

This region is of great significance clinically because it marks the divide

over which prolapsing masses of anal or rectal mucosa fall through the sphincter region. Immediately above this line lies the annulus hæmorrhoidalis where internal hæmorrhoids develop and caudal to the line is the site where external hæmorrhoids develop. The anorectal line may be carried out of position as may the line of junction of cornified and uncornified skin by pathological processes, but the pecten of Stroud or the white line of Hilton

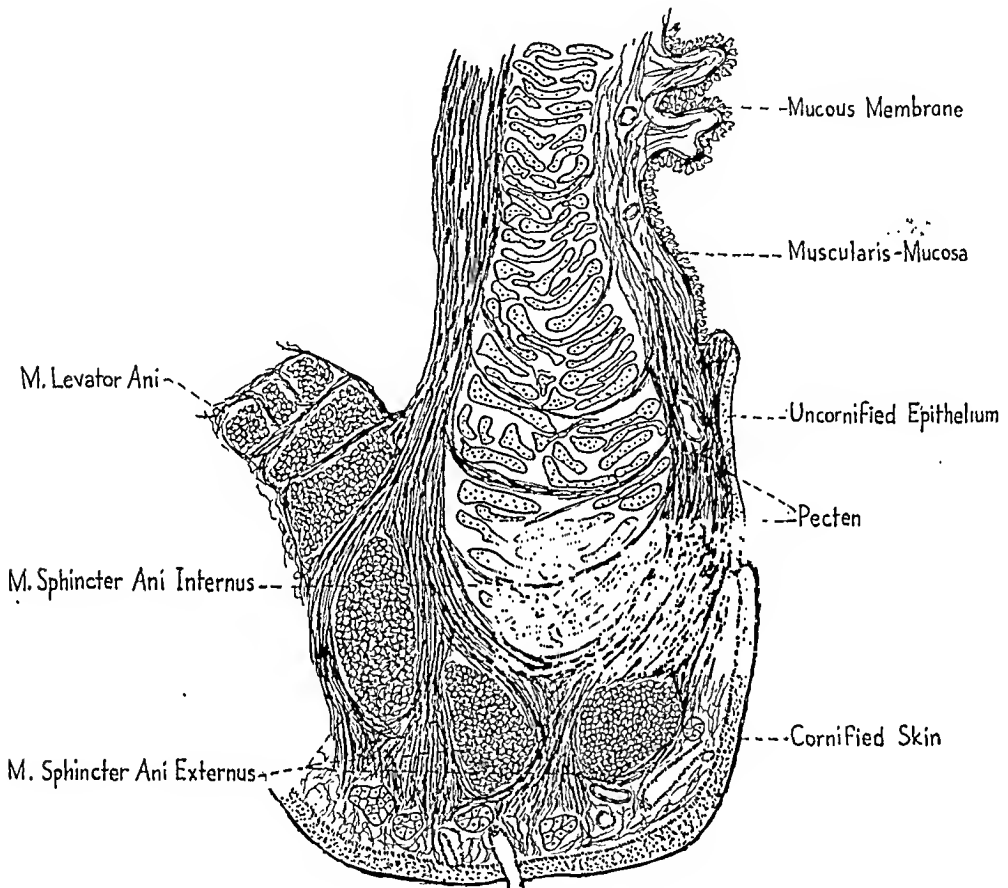


FIG. 4.—Drawing from a section of the anus showing the disposition of the fibrous terminations of the external longitudinal muscle coat of the bowel.

is a true landmark. The only point upon which Hilton was inaccurate was in his description of his line as the junction of the skin and mucous membrane.

SUMMARY

In the living, the white line of Hilton is a definite anatomical landmark. Post-mortem anatomical relationship of anal structures differs from that found in the living because of relaxation of the sphincter muscles. The heavy area of fibrous tissue deposition beneath the uncornified epithelium of the anus begins at the termination of the muscularis mucosæ and receives contributions from the fibrous terminations of the external longitudinal muscle coat of the bowel and probably also from the levator ani muscles. The white line of Hilton and the pecten of Stroud are probably identical.

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FRACTURE OF THE ANTERIOR INFERIOR SPINE OF THE ILEUM

SPRINTER'S FRACTURE

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THE widespread development of athletics makes it desirable that certain injuries which occasionally occur in athletic activities be more generally known. In preparatory school boys such injuries are particularly likely to occur because of the non-union of various epiphyses in the age group to which they belong. Fracture of the anterior spines of the ileum would appear to be a very uncommon condition if one were to judge either by the scant mention it receives in the few text-books on fractures in which it is mentioned or by the scarcity of reports in the literature; there have been very few cases of this disorder reported in this country. The two cases reported here, however, occurred in a small community within seven months time.

Forty-eight cases of fracture of either the superior or inferior anterior iliac spine have been reported: Carp¹ in 1924 collected twenty-one cases; in 1933 Christopher² collected twenty-four more and recently Rothbart⁶ has reported three more cases. The majority of these injuries occurred during rapid running (hence the term "sprinter's fracture"), but others have developed following kicking, turning backward while running, jumping, or slipping. Practically all the cases occurred in males from fifteen to twenty-three years of age, the latter being the age at which these epiphyses unite. The anterior-superior spine is more frequently fractured than the inferior; however, in the two cases reported here and in those of Pezcoller,⁵ Rothbart⁶ and Corlette,³ the anterior inferior spine was involved.

Christopher² believes that one factor in producing this condition may be the tension exerted by inelastic muscles at the point of their attachment, and he advises that runners be well warmed up before participating in sprints.

The fracture of one of the anterior iliac spines will be suggested by sudden pain at the hip occurring during such an activity as running, with a subsequent development of pain in the inguinal region, pain and difficulty on attempting to flex the thigh, and pain over the affected spine. Symptoms of a mild vasomotor disturbance such as syncope or vomiting may occur. In the presence of fracture of the anterior superior spine the fragment may be found to be movable under the examining finger.

CASE I.—P. E., a sixteen-year-old schoolboy, was entered in a 220-yard dash May 4, 1933. Previous to that day he had never experienced any difficulty in running. He was well warmed up before the race and had run about 150 yards when he suddenly experienced sharp pain at his right hip, stumbled, and faltered to the finish. He then limped off the track, dropped onto the grass, vomited, and was unable to arise. On examination at the hospital, there was tenderness on palpation at the right groin and the patient was unable to flex his thigh. Roentgen examination showed a separation

of the anterior inferior spine of the right ileum (Fig. 1). The patient was put to bed with his knee flexed for six weeks, and was then allowed up and about on crutches for two weeks. At the end of another six weeks the function of that leg was perfectly normal.

CASE II.—D. H., a seventeen-year-old schoolboy, had occasionally noticed pain at his



FIG. 1.—Roentgenogram taken of Case I directly after his injury.



FIG. 2.—Roentgenogram taken of Case II directly after his injury.

right hip during the autumn track practice periods, but had always stopped running at the onset of pain and obtained relief within a few minutes. November 30, following an adequate warming-up period, he participated in a relay race. The start in this race was from the conventional upright position, with trunk rotated and right leg posterior. About fifty yards after starting he felt extreme pain at the right hip which hampered his stride greatly, but he was able to finish the race. At the finish he was obviously in great discomfort, and felt very faint. On examination there was exquisite tenderness at the right groin; the anterior superior spine was not tender or movable; the patient was unable to flex the thigh. A roentgenogram (Fig. 2) showed a fracture of the anterior inferior spine of the right ileum. The patient was put to bed with the knee flexed, and two days later a plaster spica was applied. The case was removed after four weeks and crutches were used for the next two weeks. Special exercises were given which rapidly overcame the atrophy of the thigh muscles. An X-ray examination (Fig. 3) January 12, 1934, showed extensive callus formation, and within ten weeks following the injury the function of the leg was again apparently perfectly normal.



FIG. 3.—Roentgenogram taken of Case II seven weeks after his injury occurred. The formation callus may be seen.

Comment.—Two cases of fracture of the anterior inferior spine of the ileum are reported. Both of these injuries occurred during foot races and in both instances the boys were well warmed up before the start of the race. The symptoms and signs were very similar in these two cases: pain at the right groin, inability to flex the thigh and mild vasomotor disturbance. The

roentgenograms, which are reproduced, show the separation of the anterior inferior spine. It has been suggested that a cold muscle may be responsible for the extra strain at the epiphysis and may cause a fracture, but although that is no doubt occasionally an etiologic factor, the injury occurred in these two cases in well warmed muscles. The frequency with which this type of injury has occurred in runners suggests that one factor may be the overdevelopment of the muscles attached to the epiphysis, which before its complete union is incapable of withstanding the strain put upon it. Eliason⁴ believes that this fracture is frequently caused by a sudden forcible contraction of the rectus femoris muscle, such as occurs in sprinters at the start of a race. It may be significant that in a case reported by Christopher² and in Case II of this report, mention is made of the fact that for some weeks prior to their accident both boys had noted pain in the region at which the fracture subsequently occurred; the question might be raised as to whether a mild epiphysitis may have been present for some time prior to the accident and played a part in the subsequent fracture.

The histories of those two injuries suggests that many a "pulled tendon" occurring under similar circumstances in boys in this age group may be, in reality, an avulsion at an epiphysis. At any event, roentgenograms in such instances would be of interest. The principle of treatment employed is the relaxation of the flexors of the thigh for a period sufficiently long to allow union and healing of the separated epiphysis; this is best achieved by the maintenance of the knee in a position of ninety degree flexion by the proper adjustment of a Gatch bed or by pillows, methods which will prove more satisfactory than treatment in a plaster case.

SUMMARY.—(1) Two cases of fracture of anterior inferior spine of the ileum together with the signs and symptoms of this disorder are reported.

(2) The suggestion is made that this type of fracture is not as uncommon as the scarcity of reports would indicate.

(3) A few of the factors having an etiologic relationship to this disorder are mentioned.

(4) The desirability of using the roentgenogram in similar cases, rather than assuming that the injury is only a "pulled tendon," is suggested.

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MANAGEMENT OF DEPRESSED FRACTURES OF THE SKULL AND OLD SKULL DEFECTS

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CRANIAL injuries are frequent in these days of high speed and reckless driving. It is true that the extent of associated brain damage is the most important criterion in the prognosis of a given case of head injury. However, in not a small number, the deformities and defects in portions of the cranium not covered with hair constitute an important problem. A surgeon should always be cognizant of the influence of such deformities on the personality of the individual and his mental state, for in some they can easily cause mental problems of serious import. A discussion of the management of old skull defects is not complete without a consideration of the proper management of depressed fractures of the skull, for the latter are practically always the forerunners of skull defects. If depressed fractures are treated with careful planning before operation, plastic repair at a later date would not be necessary in the majority. Therefore, in this paper a critical discussion of the operative treatment of acute depressed fractures of the skull will precede the consideration of the management of old defects.

MANAGEMENT OF ACUTE DEPRESSIONS

In the management of an acute case of simple or compound depressed fracture we should not only think of the treatment necessary to save the patient's life but we should also be conscious of the necessity to hold to a minimum the resultant defects and deformities in portions of the cranium, which would alter the appearance of the individual. It is not the contention to have necessary and careful work suffer at the expense of final good appearance. It is true that in some cases it is perfectly proper to treat the patient without regard to resultant change in physiognomy. However, there are sufficient number of cases which can be treated in the acute stage in a way to insure not only a good esthetic result but also to obviate later operative work to improve the patient's appearance.

In a series previously reported,⁶ about 40 per cent of the simple and compound depressed fractures occurred in the anterior third of the skull. These ranged from very severe fractures destroying the frontal sinuses or the superior orbital rim or both to those of the puncture variety where only a piece of bone one inch or less in diameter was depressed. From the standpoint of clinical manifestations the cases ranged from practically moribund to asymptomatic types.

In the management of acute cases of depression four general plans of attack are at our disposal. These have been described repeatedly in various

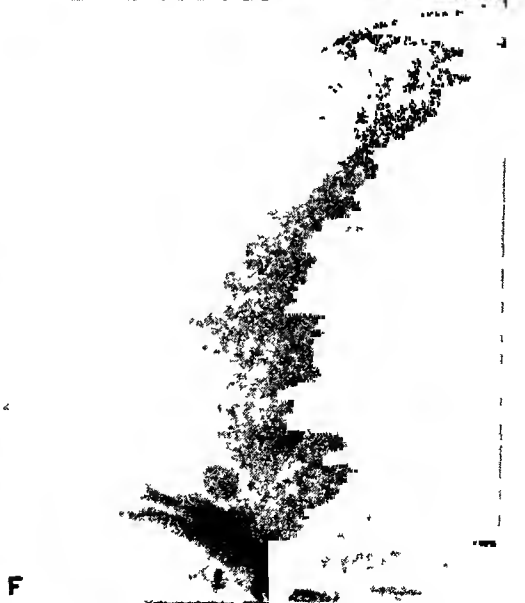


FIG 1—Case of compound depressed skull fracture, left frontal region. Through a horseshoe incision the area of depression was exposed. A large trephine removed a button of bone including a portion of normal skull. The remainder of the depression was then elevated and after readjusting the depressed portion of the removed button of bone the latter was replaced. The photographs show a normal contour of the forehead. This depression was about two inches in diameter and extended well into the forehead. A marked deformity would have ensued if the area of depression had merely been rongueured away.

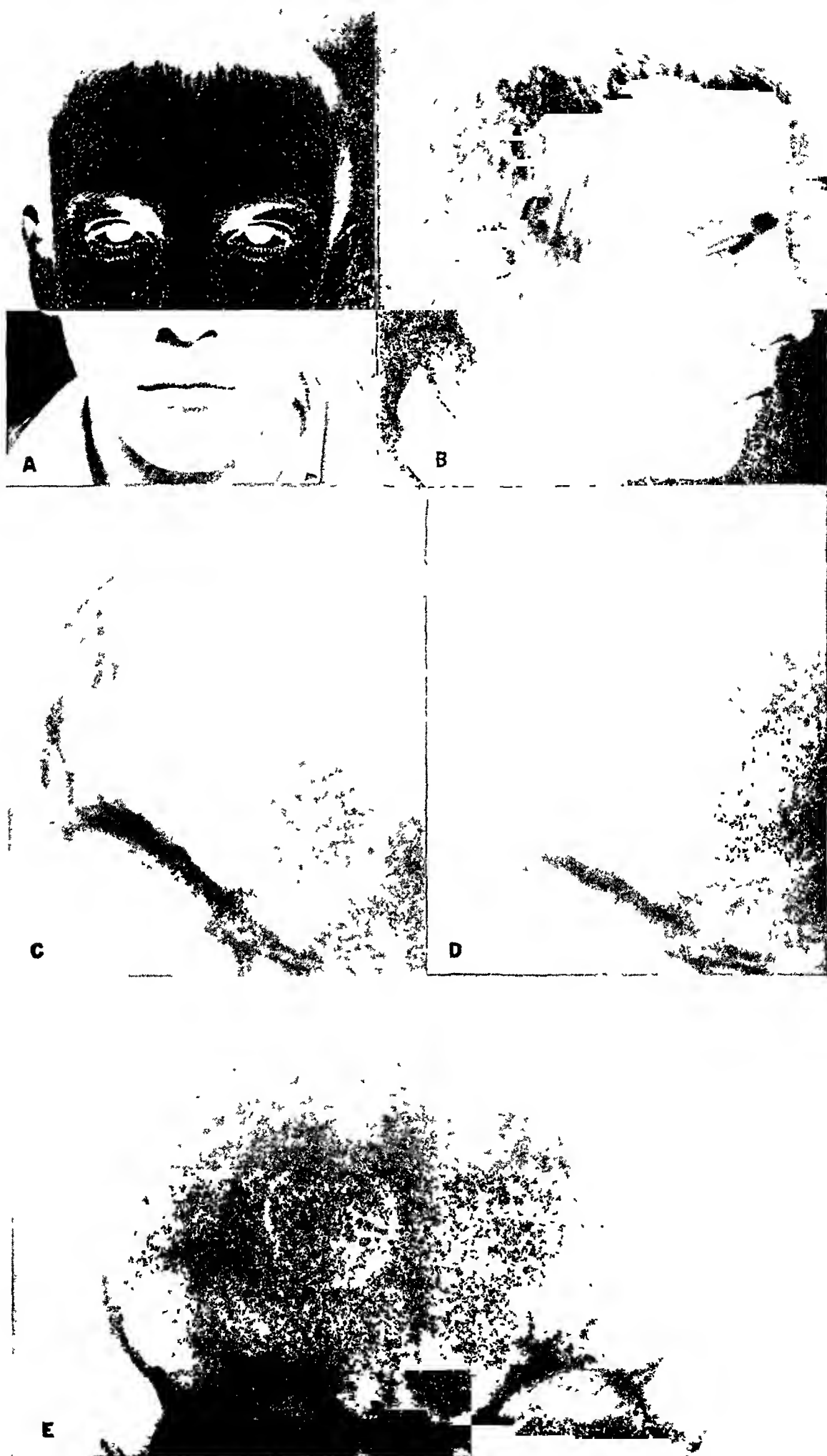


FIG. 2.—Case of compound depression of the right forehead. The area of depression was less than two inches in diameter. The entire area was trephined and following readjustment of the depression in the button of bone, the latter was replaced. Here again a bad deformity would have ensued if the depression had merely been rongeuired away. The photographs show the final result.

contributions but I feel that it is worth while to give them a critical consideration.

First, Removal of the Area of Depression.—Unfortunately, this is the most common method used. The area of depression is rongeured away without any consideration given to subsequent deformities and defects in the skull. In the portion of the skull covered with hair such procedure is not of serious consequence but in the forehead region such destruction of contour will necessitate a further operative procedure for esthetic purposes or will leave



FIG 3.—Demonstrating the method of obtaining the transplant from the outer table of the skull. After freshening the border of the defect with the same trephine, a good fitting is obtained when the transplant is placed in the area of the defect. This method can be used in cases with small defects. In the fresh case, if the bone in the region of the depression is missing or contaminated beyond use such a repair may be obtained immediately, particularly when the patient is asymptomatic or relatively so

the patient with a permanent disfiguring defect. A certain amount of forethought and careful planning before operation can in many instances obviate this possibility.

Second, Elevation of Depression by Means of a Bone Elevator Passed under the Area of Depression Through a Small Opening to One Side of the Defect.—The method of approach has its best application in children. The so-called "derby hat" type of depression can be thus treated with excellent results. However, in the adult the inner table of the skull is so often shattered and depressed without an associated depression of the outer table of equal severity, that working blindly through a small opening one can easily cause damage to the dura, diploic bleeding and at times elevation of the outer table

with little or no elevation of portions of the inner table. Furthermore, this method does not allow the operator to inspect the dura. I use this method in children and also in some adults after careful examination of the radiographs. It is inferior to the next method of approach.

Third, Mass Removal of the Area of Depression Including a Strip of Normal Bone Surrounding It. After Readjusting the Depression Replacement of Bone Flap.—This method is the most satisfactory for it enables the operator to get a good esthetic result, it allows inspection of the dura and if necessary incision of the latter and inspection of intradural contents. Two methods for mass removal are: First, osteoplastic flap method, namely, making several openings in the skull surrounding the area of depression and sawing off the intervening skull with a Gigli saw. Second, the trephine method, namely, using a trephine one and one-half to two inches in diameter and removing the entire area of depression. If the depression is larger than the circumference of the trephine used, as may frequently be the case, the button of bone removed should include a portion of normal skull. This is followed by careful elevation of the remainder of the depression and replacement of the button of bone. I prefer the trephine method as it causes less shock, less bleeding and takes much less time (Figs. 1 and 2).

Fourth, If the Area of Depression Is Beyond Repair or if Pieces of Bone Have to Be Discarded Because of Contamination, the Defect May Be Treated by Transplant from the Outer Layer of the Skull.—The transplantation of bone becomes very simple if the size of the defect is within the limits of the circumference of the trephine used. In some cases because of the patient's condition one may not be able to treat the defect in the first operation, if so in the absence of infection plastic repair may be obtained within a few weeks. In cases with little or no clinical evidence of associated brain damage plastic repair at the first operation is not rash surgery (Fig. 3).

It is true that in some cases it is impossible to do all one desires, for instance, in compound depressions involving the frontal sinus region and the roof of the orbit it is important primarily to fight infection. Therefore, in such cases all foreign particles and pieces of contaminated free bone are removed. If there is a laceration of the dura, the latter is well exposed and repaired if possible. It is usually necessary to pack the wound. After such operative procedure extensive defects in the forehead are not uncommon. In such cases further work to repair the defect is necessary.

In this clinic it is the policy not to disturb slight simple depressions with no symptoms. Particularly is this true in the forehead area and the region of the frontal sinuses. Of course compound fractures depressed or otherwise are carefully débrided and cleansed in the usual manner. The work of Naffziger and Glaser¹¹ on experimental depressions is interesting and certainly is frequently proven to be correct on clinical grounds. They state that brain injury obtains at the time of the blow and that the presence of a slight depression *per se* is not productive of brain dysfunction. This is certainly true in the majority of cases and speaks favorably for conservative treatment in the



FIG. 4.—Demonstrating the gradual disappearance of autopsy skull bone used for transplantation purposes. In (A) there is beginning decalcification three months after repair. In (B) there is more evident decalcification nine months after repair. In (C) there is practically complete disappearance of the transplant 15 months after repair. There was no infection or sequestration in this case.

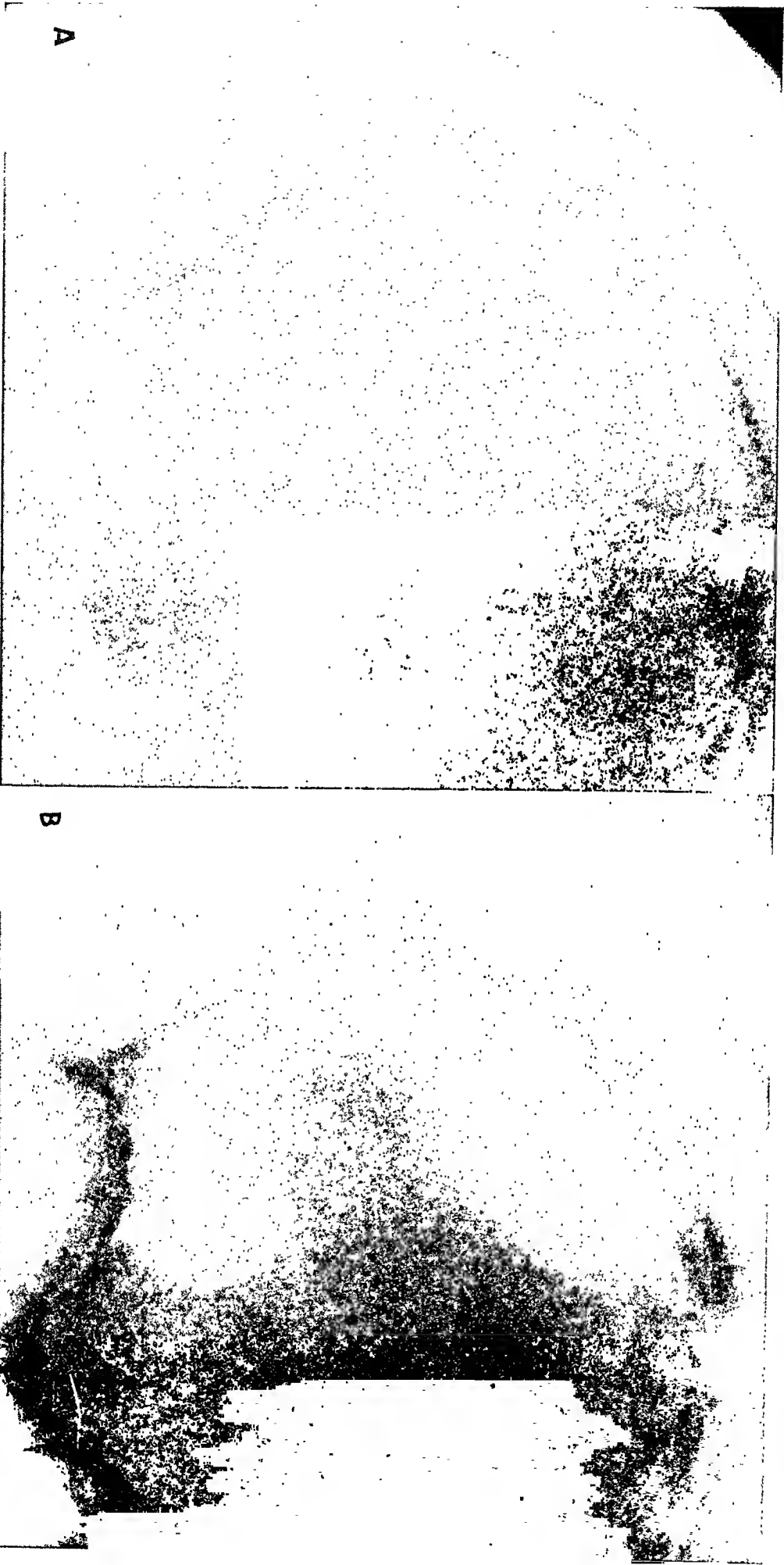
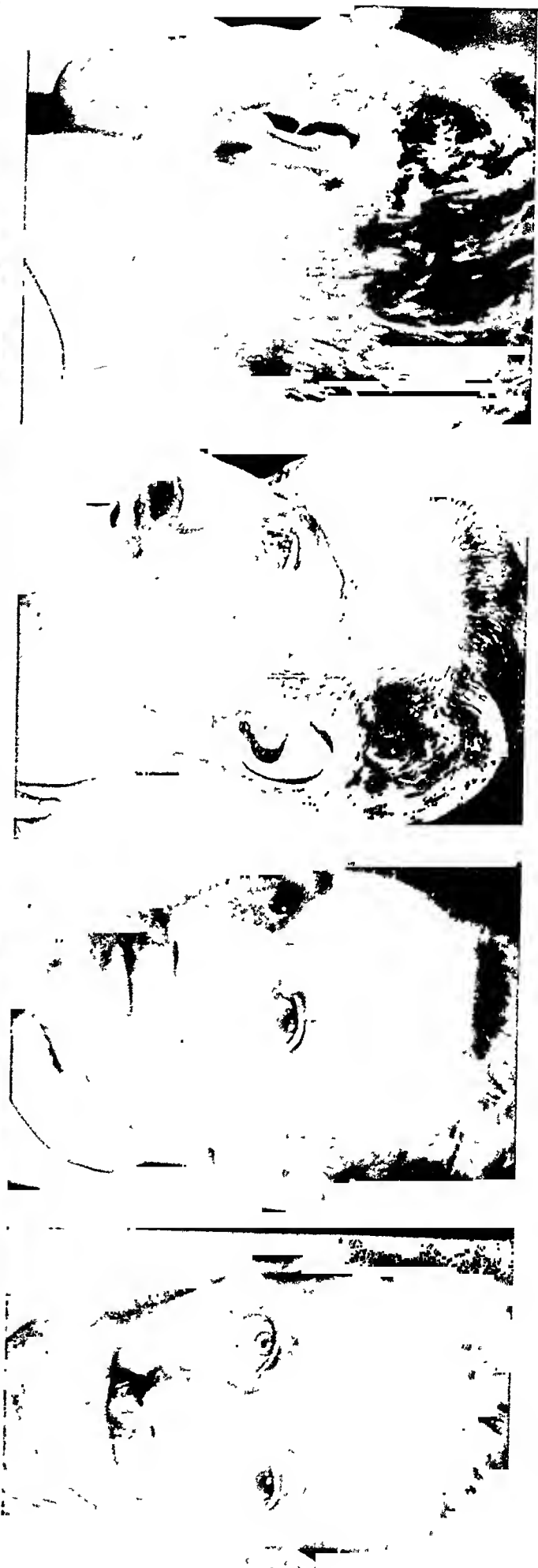


Fig. 5.—Illustrates a repair of the supra-orbital region by autogenous osteoperiosteal transplant. Note in (B) the portion of the skull where the transplant was obtained. There is good preservation of the inner table of the skull.



FIG. 6.—Showing repair of a midfrontal defect with autogenous osteoperiosteal transplant. The anteroposterior and lateral views of the patient before operation show a disfiguring defect. The anteroposterior and lateral views of this patient after operation were obtained 14 months after repair. This patient's defect was caused by compound fracture of the skull involving both frontal sinuses and exposing both frontal lobes.



A



B

Fig. 7.—Case of compound fracture involving the left forehead, supra-orbital rim and frontal sinus. He developed a frontal lobe abscess which was drained. After three months repair of the forehead was obtained by using autogenous osteoperiosteal transplant. (B) shows bony union in the region of the defect. Photographs show condition and appearance before operation and final result after operation. Last photographs taken 16 months after repair. Patient shows some external strabismus. Before operation there were marked pulsations of the eyeball on the left but this has practically completely disappeared since repair.

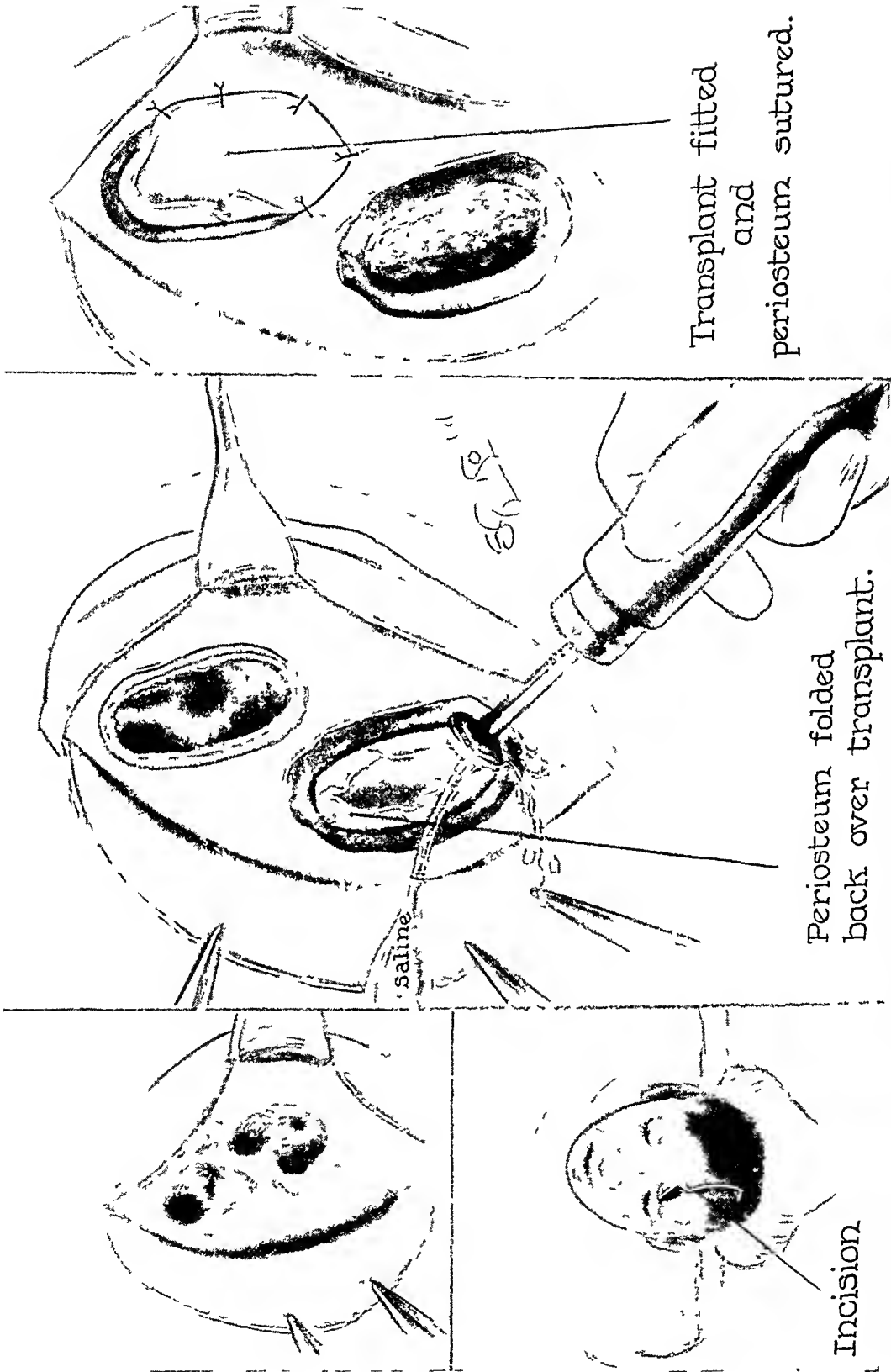


FIG 8.—Shows repair of a defect in the forehead. The use of a rotary saw we feel is very important in the obtaining of the transplant. By cutting down to the diploe with a saw the transplant obtained is much firmer and more solid. There is less likelihood of a deeper penetration with a chisel if the rotary saw is used first.

case of slight depressions. In a previous paper it has been shown that simple slight depressions and simple fractures in the region of the frontal sinus do well with conservative treatment. Where there is spinal fluid rhinorrhea associated with fractures in the frontal sinus region it is good surgery after careful examination of the radiograms to expose the tear in the dura and repair it if possible, or pack it against the brain as suggested by Peet.¹³

MANAGEMENT OF OLD DEFECTS OF THE SKULL

The indications for repair of old defects of the skull are first, better esthetic results and second, alleviation of symptoms of headache and dizziness in cases with large defects. The various authors consulted also list traumatic epilepsy as one of the conditions cured by repair of old defects, although I doubt the efficacy of this mode of treatment, for permanent cure, in convulsive sequelae of head injury. A great deal of work on repair of old defects has been reported in the past thirty years but the greatest advance has been made with the large amount of material during the Great War and since that time.

Various transplants have been used. Inanimate objects, such as, silver plate, aluminum plate, vulcanite, *etc.*, have been used (Mitchell,¹⁰ Elsberg⁴). Heterogeneous transplants have been advocated by using flat bones from sheep, oxen, birds, *etc.* (Babcock,¹ Pankratiev¹²). The use of bones from human autopsy material has been advanced by several investigators (Westerman, Pankratiev). Transplants from the body of the same individual have been obtained from tibia, rib, scapula, iliac bone and outer plate of the skull (Breniger,³ Rhodes,¹⁶ McWilliams,⁹ Jones,⁷ Primrose,¹⁴ Bagley²). Auto-genous osteoperiosteal transplants from the outer plate of the skull were advocated as early as 1905 by Keen.⁸ Since then a great deal has been learned about this method of approach (Frazier,⁵ Primrose, Reed,¹⁶ Peet¹³). I feel that of various material used, autogenous osteoperiosteal transplants work best. In the present material I employed osteoperiosteal transplants in eight cases, dead boiled skull from human autopsy material in two cases, and rib in one case. Dead bone (Fig. 4) and rib transplants disappeared within 18 months after application. The osteoperiosteal transplant from patient's own skull, however, seemed to carry on and in four cases there is evident bony union as evidenced by radiography.

Briefly, the operative technic is as follows (Fig. 8). Through an appropriate incision the defect is fully exposed. The contour is freshened by rongeur away a thin strip of bone. The periosteal lining along the defect is carefully saved. Either through extension of the same incision—or, if not practical, through a separate horseshoe flap—a portion of the skull is exposed, preferably the parietal bone near the midline. Care is taken not to disturb the pericranium when the bone is exposed. The outline of the defect is placed on the exposed bone, the periosteum is incised along the outline or about a centimeter beyond it. The periosteum is then puckered toward the center of the bone to be removed. With a rotary saw the bone is cut down to the diploe along the outline of the transplant needed. With a sharp chisel the transplant

is then removed, consisting of the outer table only. The inner plate bleeding may be stopped with bone wax. The transplant is then placed in the defect after any necessary adjustments are made for better fitting. The periosteum of the transplant is then sutured to the periosteum along the defect.

If the defect is sufficiently small a trephine of the proper size may be used, both to freshen the inner margin of the defect and to obtain the transplant from the outer table of the skull. I use the free graft although for defects in portions of the skull covered with hair the flap graft may be used with advantage. The latter may be found to be more successful than the free graft. In the region of the forehead, the flap method cannot be used advantageously because the bone is usually thinner in this region and there is less likelihood for a smooth clean result from the esthetic standpoint.

The fate of transplants from the outer table of the skull can be followed fairly accurately with radiograms (Figs. 5, 6, and 7). It is my impression that in the successful case the transplant remains viable throughout, obtaining its nourishment from the surrounding vascular tissue. This impression is based on both radiographic findings and reopening of some of the cases for further plastic repair. In the latter the transplanted bone was found to bleed as one would expect it in a living bone. That the transplant behaves like a host for osteogenesis such as described for long bones does not seem to be the case in transplants of the skull.

SUMMARY AND CONCLUSIONS

Careful planning before operation in cases of acute depressed fracture may frequently solve the problem of allowing the minimum postoperative deformity. As has been brought out in the text, mass removal of the area of depression and replacement of the flap following readjustment of the depressed pieces gives excellent esthetic results. Such a procedure is particularly commendable when the patient is asymptomatic or shows few clinical evidences of brain injury. In such a case the debatable question of decompression does not arise.

In old defects and in those acute cases which cannot be treated without causing deformities of the skull, autogenous osteoperiosteal transplants obtained from the outer table of the patient's own skull give excellent results. It is true that occasionally spontaneous osteogenesis does obtain even in extensive defects of the skull. Particularly is this true in children; in adults it is rather unusual. However, if spontaneous osteogenesis does take place, the usual convex contour of the skull is lost and in portions not covered with hair such spontaneous repair of the skull is as disfiguring as no repair at all. It is, therefore, perfectly proper to repair such cases as soon as possible and not lose time waiting for spontaneous repair to occur.

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FRACTURES OF THE BODIES OF THE VERTEBRAE *

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A CONSIDERATION of fractures of the bodies of the vertebrae must include their anatomic structure, blood supply and development. Investigations on these subjects have been going on from various angles. Probably the most authoritative work has been Schmorl's,¹² but in this country Eben Carey, W. A. Evans,⁶ A. G. Davis,⁴ John Dunlop,⁵ George Wagner and E. P. Pendergrass,¹⁴ with R. W. Jones,⁹ Böhler² and others in Europe, have simplified and rationalized treatment.

The blood supply and development of the vertebral bodies has been restudied both anatomically and roentgenologically by several investigators until it has become possible to recognize the so called epiphyseal plates on the transverse surfaces with their small notches in the anterior border of the body and the site of entrance of arteries and exit of veins near the center. The large venous sinusoids occupying more than a quarter of the volume of the corpus have also come to recognition in the roentgenogram and in clinical consideration.

Along with this information much has been learned about the intervertebral disks, their elasticity, structure, variation and changed appearance after various traumata or congenital misplacements. They are known to represent one-sixth to one-fifth of the length of the spinal column and their self-contained character without definite blood supply and their relatively perfect incompressibility, if unruptured, have assisted in the study of the mechanism of fractures of the body.

Daily study of roentgenograms of the spine in two axes brings out differences in details of the primary bone displacement in fracture and its effect on prognosis and treatment. The finely meshed cancellous bone of the vertebral body, weakened by unclosed epiphyses and venous sinusoids in adolescence and affected in later life by senile changes found in all bones of similar structure, is subject to injury by both direct and indirect violence, the latter most often.

A survey of the mechanics of compression fracture of the corpus consequently exposes the several elements that enter into the injury. These are:

(1) The arrangement and anatomy of the trabecular scaffolding of the bodies.

(2) The circulation to and situation of the venous sinusoids in the vertebral body.

(3) The direction of the lines of force of trauma from direct compression in the long axis and those of pure flexion and compression flexion combined with their effect on the corpus vertebrae.

* Read before the Western Surgical Association, St. Louis, Mo., December 8, 1934.

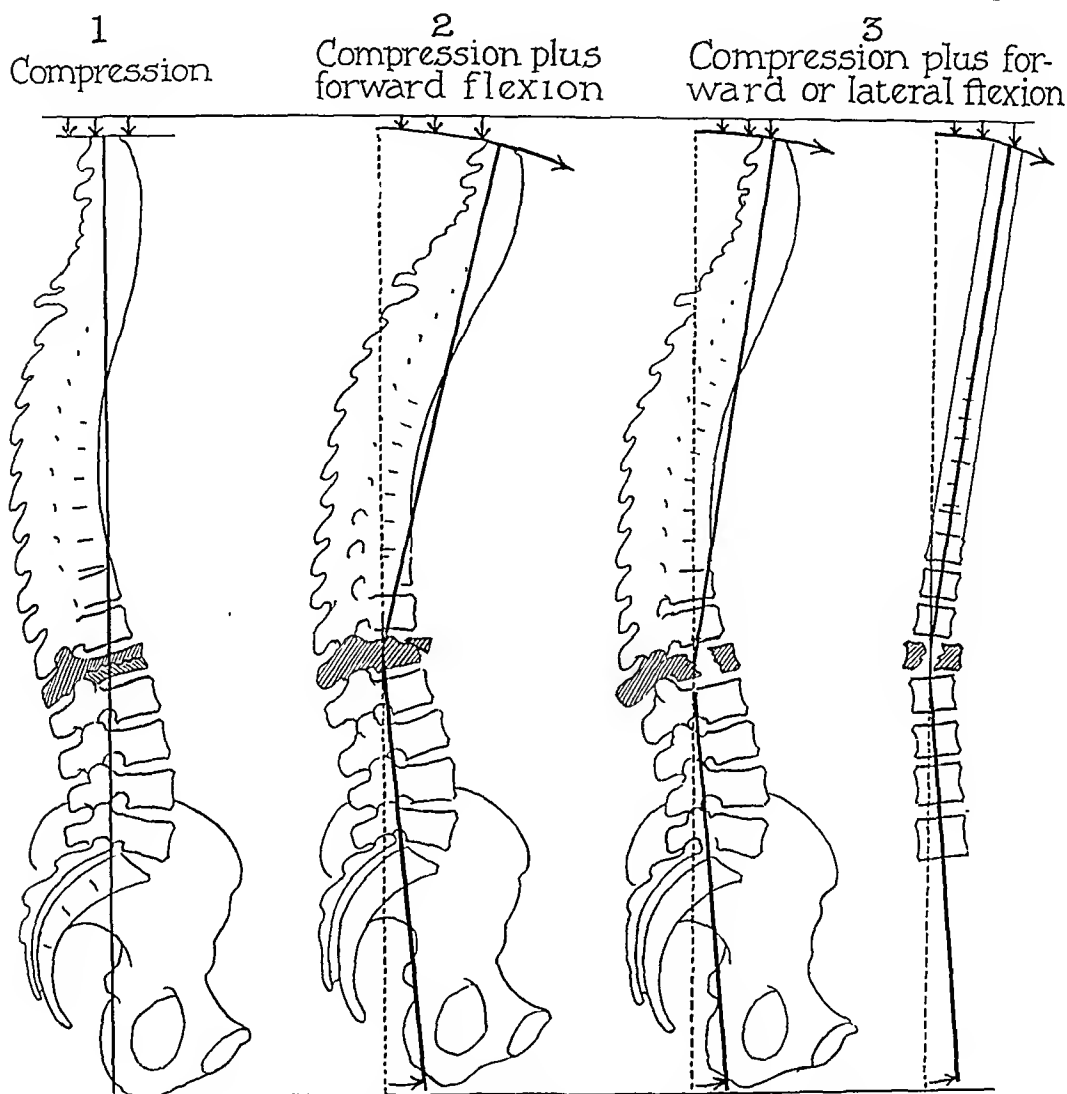
(4) The leverage action induced by flexion of the whole trunk forward aided by the architecture of the posterior articulating pedicles and facets attached to the arches and bodies, the rigidity and tensile power of the posterior and interspinous ligaments and the almost uniform tendency of the human body to fall in a position of flexion forward or laterally forward.

The middle portion of the corpus support weakened by venous sinusoids, and the late ossification of the middle of the body anteriorly where vessels enter, may be determining factors coupled with those given which cause the breaking off of a wedge-shaped piece from the upper anterior edge of the body caught in flexion pressure, or cause squashing compression of the whole body submitted to the more or less equal hydrostatic pressure of the intervertebral disks in pure compression applied in the long axis.

The main mechanism of fracture of the corpus vertebrae is undoubtedly compression. The rarer instances of injury from direct violence or fractures of the accessory portions of the vertebrae require less consideration. Compression sufficient to cause fracture must be applied directly in the long axis of the spine, aided by the incompressible intervertebral disks, and it is often complicated by flexion, generally forward, rarely lateral or hyperextension. Compression conveys force to those vertebrae which are located near the apices of the normal anatomic curves of the spinal column, especially from the dorsal tenth to lumbar fourth inclusive, which are less well supported by the ribs and contiguous structures resulting in crushing of the cancellous bone of the body and retention of an intact intervertebral disk. If no flexion accompanies compression, then the body is crushed and lessened in height quite uniformly, the posterior border in lateral view being reduced equally with the anterior border. The corpus tends to broaden laterally as does a crushed calcaneus and it may be separated into two or more fragments, one of which may push back into the canal to compress the cord, while the other may be displaced forward as far as it can go under the restraint of the anterior spinal ligament. There is no breaking off of triangular fragments at the border. If flexion forward and compression act together, there is broken off from the the anterior superior border of the corpus a wedge-shaped piece varying from a pea-size to nearly the whole anterior portion of the body, the plane of separation extending diagonally down and forward. The main portion of the body, especially the posterior, retains its height or diameter and the spinal canal is protected by the intact posterior longitudinal ligament while the anterior height is diminished with accompanying displacement forward of the whole spinal segment above, and resulting gibbus formation behind from the separated spinous processes after the interspinous ligaments are stretched or torn.

When compression is accompanied by lateral flexion the amount of comminution may be increased, one side of the body is crushed down more than the opposite side and displacement laterally into subluxation may be found. The body breaks into fragments easily through its weaker center, the seat of venous sinusoids. Other adjacent bodies may suffer similarly. One side

of the corpus of the vertebra may be found in the roentgenogram compressed and lessened in height when compared to the opposite side. The first roentgenologic study must compare the bodies immediately adjacent above and below the injured segment to search for breaking down of the bone along either superior or inferior border with early increased density, suggesting



MECHANISM AND RESULT OF FRACTURES OF THE CORPUS VERTEBRAL

Adapted from Roentgenologic Tracings

FIG. 1.—Pure compression fracture from violence received in long axis of spine without flexion. On lateral view the crushed corpus is narrowed quite uniformly compared to its neighbors; the posterior height is lessened yet equal to the anterior; the intervertebral spaces remain equal. The density of the bone may be increased from the intermeshing of cancellous tissue and the normal longitudinal axis of the spine may not be disturbed at all.

FIG. 2.—Flexion fracture with minor degree of compression. The anterior superior edge of the corpus is broken off; the fragment is displaced slightly forward; the posterior height of the corpus is normal and the intervertebral spaces usually remain equal to those adjacent. The main portion of the body does not change bone density. The superincumbent portion of the spine is flexed forward to a varying degree and there is a corresponding amount of gibbus formation at the fracture level. The arrows indicate diagrammatically the main lines of the force causing fracture. This is the common type.

FIG. 3.—Less common type with break through the weak center portion or fragmentation of the corpus and displacement of fragments. There may be a typical lessening of height of the body, fracture of the facets and pedicles and more evidence of cord pressure. Some instances viewed in the anteroposterior plane show lateral axis deviation of the superincumbent portion and the corpus may be correspondingly lowered in height on one side compared to the other.

Obviously, Types 1 and 3 require more care, greater traction and a longer freedom from weight bearing to restore the volume and integrity of the corpus vertebrae. Type 2 as a rule offers a better prognosis and a much shorter convalescence.

impaction of the cancellous tissue into itself. Later bone density changes indicate aseptic necrosis or if accompanied by new bone formation may require two to four months for demonstration in the film and depend on the amount of blood extravasation at time of injury, the period of immobilization used in treatment, and the secondary postural changes in the spine. The intervertebral disk may be ruptured and the nucleus pulposus evacuated.

The recognition of the retaining value of the anterior and posterior spinal ligament, of the intact pedicles and facets which afford leverage power during extension of the spine, induced Davis⁴ to treat his patients by hyperextension in a prone position, hanging them up by their feet. This position pulled back into place the displaced fragments of the body, especially those caused by hyperflexion of the spine. Dunlop⁵ used manual extension on all four limbs under anesthesia, accompanied by sudden forced hyperextension on a blanket or sheet, obtaining a maximal reduction in one quick action. Later special beds, such as Rogers¹¹ devised, were employed while the patient lay supine, to hyperextend the spine and by the felicitous action of its own ligaments and intact articular connections obtain reduction, with overcoming of the gibbus and angulation at the fracture site. Five years ago R. W. Jones⁹ in Liverpool advised an easy correction without any anesthesia by letting the patient hang between two tables, one higher, supporting the head by resting on the crossed arms, while the legs up to the groin lay flatly on a table at a lower level. The weight of the midportion of the body brought sure and complete extension of the spine with reduction of displacement.

All these types of reduction by means of hyperextension with any required lateral flexion may be followed by plaster-of-Paris dressings much like that advocated by Böhler,² an encircling torso jacket resting on the hips, extending in front to the xiphoid notch and behind to the level of the inferior angle of the scapula, with a cut-away area for abdominal distension after eating. Many surgeons prefer to keep their patients supine on a plaster bed for six or more weeks in the position of hyperextension, to ensure which the plaster bed may be extended to the popliteal space under the thighs and half around the head above. Others have permitted immediate ambulation in the short torso plaster with the spine hyperextended. Operations on recent fracture to stabilize the spine by an implaced bone graft or a Hibbs operation have practically passed into disuse.

It will require the assembling of a large series of fractures of the bodies of the vertebrae treated by prolonged recumbency or by immediate ambulation after reduction by means of hyperextension to determine which method should be employed as routine. Series of roentgenograms over several years after reduction must be made to determine the final health and outline height as well as the structure of the compressed bodies. Clinically the amount of persisting pain must be gauged in this determination, always considering the original amount and character of the compression and displacement of bone. Discussion of Kummell's disease has purposely been avoided here. For over

20 years I have maintained that it resulted from mild and roentgenologically unrecognized compression fracture, permitted to go untreated.

After perusal of the many articles on this subject and an effort to analyze my own cases, it is my opinion that a few points in treatment require stressing. Each fracture of vertebral body should be studied roentgenologically before reduction to determine whether it was caused by pure compression in the long axis—with a squashed body easy to demonstrate early in the roentgenogram—or whether it was caused by compression flexion with a fragment broken off the superior surface of the body and displaced forward and downward. The third class of combined flexion and compression with lateral displacement may be recognized often by graver cord pressure symptoms but must be seen also in the roentgenogram.

If the fracture is the result of compression flexion with a relatively small fragment broken off the upper anterior border of the body, reduction by hyperextension by Jones' method or on a spinal bed which can be rapidly elevated into hyperextension at the site of fracture followed by an ambulatory plaster-of-Paris torso jacket for 10 to 14 weeks is sufficient treatment for most cases, during which time the patient requires no special exercises for his spinal muscles. In some individuals the amount of retroperitoneal hemorrhage from the fracture may induce abdominal symptoms, even a paralytic ileus, which will prevent all efforts at making the patient ambulatory and cause alarming complications. After removal of the plaster a roentgen ray study is made of the lesion and if the body of the vertebra seems restored to height and proper density with evidence of beginning reformation of normal trabecular lines, a spinal brace is applied and left on while the patient is on his feet until the roentgenogram shows full restoration of health and trabecularization of the bone. This may require a total of three or more additional months. With the passage of time the identity of fragments is lost, callus forms in the corpus, but some crushing deformity may persist. Hypertrophic new bone formation slowly appears and seems to envelop the body or advance along the anterior and posterior ligament to lock in the crushed bone.

For those patients who have sustained great compression with broadening or lateral gross displacement and uniform loss of height of the corpus, reduction by hyperextension plus traction in the long axis of the body is required in most cases. This is best done on a spinal bed with traction on head and feet. It does not seem necessary to hurry this reduction by sudden jolting hyperextension as it usually takes place smoothly in a few hours where sufficient force is employed. Evidence of cord pressure is a strong indication for this treatment. The symptoms may clear up rapidly. Immediate forceful hyperextension under traction and anesthesia is not advised.

A plaster bed or torso corset embracing the thighs may be used depending on the amount of dislocation laterally. These patients should be kept on the plaster, supine for eight to 14 weeks; ankylosis need not be feared. They may be rotated from side to side for gentle massage and back hygiene, not changing the position of hyperextension. Later they are fitted with a plaster-

of-Paris corset or back brace which is worn until roentgenologic demonstration of healed bone trabeculae is in evidence. This may require six to 12 months, depending on the patient's age and the amount of crushing of the body. If the back is unsupported there is a tendency for reformation of deformity, excess new bone formation, or wedge-shaped vertebral body along with continuation of pain. The spinal brace does not really interfere with action of the supporting spinal muscles, but acts as a constant reminder to the patient to stand in erect posture while ambulatory or sitting. During rest periods and at night the patient lies on a flat pillowless bed, brace removed. The structure and character of the repair in the corpus demand this safeguarding. Long continued extension and freedom from weight bearing are required to avoid extensive new bone formation and ankyloses between bodies, especially under the anterior ligament, and to maintain the normal height and size of the body if it has been regained by treatment.

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ARTHROPLASTY OF THE HIP AND THE PRESERVATION OF ITS STABILITY

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IN ANALYZING the reason for skepticism on the part of some regarding the wisdom of mobilizing ankylosed hips, one finds considerable difference of opinion among the best of surgeons. In most instances, however, the failure to secure active muscular stability, which many times results from the usual type of operation, is the reason. Henderson, reviewing the end-results of arthroplasties of the jaw, elbow, knee and hip, found those for the hip the poorest. The problem is obviously more complicated in weight bearing joints. The occupation and social status of the patient, as well as his temperament, are often determining factors, in deciding whether or not to operate, where the relationship of the femur to the pelvis is favorable. When the hip and knee on the same side are both ankylosed, the advantages of arthroplasty are much enhanced.

Stability by muscle action is very important at the hip, and, although the rotary nature of the joint lends itself to arthroplasty, unfortunate results have followed arthroplasty when stability was not obtained.

Arthroplasty in cases of tuberculosis should be approached with a great deal of conservatism and only when the roentgenogram shows evidence of complete disappearance of all disease and a complete homogeneity of bone structure throughout the operative field should operation be advised.

Murphy in 1904 reported his technic for arthroplasty of the hip, and in 1906, Hoffa¹ reported five arthroplasties of the hip (three by Rochet, and two by Nelaton²). From that time on, an increasing number are found in the literature. In fact, in my hands arthroplasty of the hip has become so dependable and well regarded that whenever doing an operation to stiffen a joint, if that case is a possible favorable one for future arthroplasty, I so plan my arthrodesing operation as to make it as favorable as possible for the future mobilizing operation. The points in favor of a future restoration of motion to a joint are: favorable age and temperament of patient, satisfactory degree of preservation of overlying soft parts and muscles, and satisfactory general condition of limb, including bone at site of proposed operation. In such a case, in doing an arthrodesis, I prefer to take bone elsewhere, rather than to disturb unduly periarticular structures or important surrounding muscles by obtaining the bone graft material locally. At the hip, tibial grafts are preferable, because of their adequacy of length and strength, thus making it unnecessary to incorporate them in the joint itself. If there has been an approximation of the great trochanter to the rim of the acetabulum, because

of telescoping from bone destruction, when it is ankylosed, then the graft material from the outer table of the ilium can be obtained of sufficient dimensions. Obtaining bone from the great trochanter has, besides the disturbance of the hip musculature, an additional disadvantage in that it shortens the trochanter-femoral neck leverage, an important item in muscle control of the hip. At the knee, for the same reason, I no longer employ the patella as a source for arthrodesing material. After its diseased portion has been removed, the patella is left as intact as possible.

To be classed as a good result in arthroplasty of the hip, there should be a minimum amount of voluntary flexion of at least 35 degrees. Everything being considered, a hip that possesses 35 degrees of painless, active motion, is far superior to a stiff hip. Not only should the hip joint have motion to allow proper sitting, but it should be painless and function in locomotion, particularly in bearing the weight of the body. It is far better to have a stiff, immobile hip than one accompanied by weakness and lack of satisfactory weight bearing or abduction. One author goes on to say that "the more nearly the joint is similar in size and shape to the original joint, the greater will be the stability. Hence, arthroplasty is not a resection!" This statement should be challenged. A ball and socket joint situated at the hip cannot have *per se* a desirable amount of motion and still be stable, because passive stability could only result from the capsule acting as check ligaments to motion, and this, in itself, would prevent adequate motion. Desirable stability with a large range of motion must come from muscle control. One frequently sees excellently functioning hip joints when there has been, from disease, an extensive destruction of bone and no semblance of a ball and socket joint remaining. The reason for this is that the muscle control is the all important consideration as to whether a hip is stable and whether there is a satisfactory amount of active motion and weight bearing.

To resolve the mechanics of the hip into simple terms, the hip joint itself is a fulcrum point situated at the end of a lever (namely, the neck of the femur) the distal end of which (or the great trochanter) is controlled by means of powerful muscles that are able, because of this mechanical setup, to pull or actively lift the limb at an angle with the pelvis, or abduction, which is a most important feature of locomotion in that it is the essence of weight bearing. In other words, it is impossible for an individual to bear weight satisfactorily on a limb when the hip is mobile unless the muscle control is such that the limb can be held so that it will not swing into adduction. This is brought about by the mechanical action of the abductor muscles of the hip pulling on the distal end of the lever; namely, the trochanter and the neck of the femur.

If this statement, used as a premise, is true and if it is possible to maintain this muscular control, then the careful modeling with the head of the femur fully filling a deep new-made acetabulum (with the difficulty of securing a free range of motion incidental thereto) is not necessary or desirable. The deeper the new acetabulum is made, and the corresponding femoral head

fitted to it, the less the chance of securing a good range of motion. Therefore, in selecting cases for arthroplasties of the hip, one should be sure that the muscles about the hip are reasonably preserved. Formerly, it was my practice to rule out cases in which there had been extensive shortening of the neck of the femur, either from bone destruction or from a telescoping of the head and neck of the femur into the pelvis, for the reason that even if the abductor muscles were intact one could never expect satisfactory function of active abduction because the trochanter-femoral neck lever would be still further shortened by the modeling of the new-formed hip, and thus furnish inadequate leverage for the abduction or weight bearing muscles to pull upon.

This was fully realized 20 years ago when designing my reconstruction-arthroplasty for ununited fractures of the hip with removal of the head of the femur, and placement of the denuded trochanter in the acetabulum; because of this, the leverage action of the neck of the femur that was lost was restored by lengthening the lever on the outer side of the long axis of the shaft of the femur by erecting, laterally and obliquely to the shaft, a bone muscle lever with the insertion of the hip abductors to its upper end undisturbed. Later, in order both to increase the length of this lever and to assure its maintenance, the removed femoral head was shaped as a wedge and placed so as to hold it outward. In this way, one is able in such cases, even in the complete absence of the head and neck of the femur, with the denuded trochanter placed in the acetabulum, to establish a lever equally as long as the normal trochanter-neck lever of a normal joint. Whether the resulting reconstructed joint follows a nonunion, or a shallow modeled acetabulum of an arthroplasty for ankylosis, the mechanical conditions brought about in the above manner prevent dislocation when the limb approximates the midline, which is a real hazard, unless provided against. The *modus operandi* is as follows: As the limb seeks the midline, the upper end of the erected bone graft lever travels farther and farther away from the rim of the acetabulum and the side of the pelvis, and thus not only puts an increasing tension on the short abductor muscles but also on the surrounding fascial structures, thus holding the head of the femur securely in the acetabulum.

Because of the very satisfactory experience with this mechanical setup in a large number of cases of ununited fractures of the hip, I began 10 years ago to apply the same principle to cases of arthroplasty where, because of bone destruction, the trochanter-neck lever is practically absent or much shortened, and a satisfactory result by arthroplasty alone not possible. Therefore, in recent years, the destruction of the head and neck of the femur (with telescoping) has not been a deterrent influence to me in selecting cases for operation, in that I have found in doing an arthroplasty that a hip joint could be modeled with the head of the femur much smaller than the acetabulum, with sufficient fascia and fat to fill in the interspaces, and that the mechanical influences brought about by the provision of leverage action for muscle control on the outer side of the trochanter not only prevented dislocation, but allowed active abduction and satisfactory weight bearing.

CASE REPORT

Miss H. H., aged 32 years, came to me July 11, 1924, referred by Dr. G. W. Crile. She had suffered from ankylosis of both hips, apparently the result of suppurative arthritis. In 1917, an arthroplasty had been performed on the left hip, and in 1919, on the right hip, by Dr. Carl Hoy of Columbus. Excellent motion was obtained in both hips. The right hip, however, was a serious disappointment because of instability and constant danger of dislocation whenever the limb came to or beyond the midline.

This case presented three features: (1) a constantly recurring dislocation of the hip whenever the limb swung to the midline or beyond, (2) loss of the function of abduction, and (3) loss of active weight bearing. These are the very conditions which the present bone-muscle lever was designed to overcome or prevent.

Operation.—July 14, 1924, at the New York Post-Graduate Hospital, was therefore approached with a great deal of interest by myself and my associates. The newly formed joint resulting from the previous arthroplasty was found to be an excellent false joint,

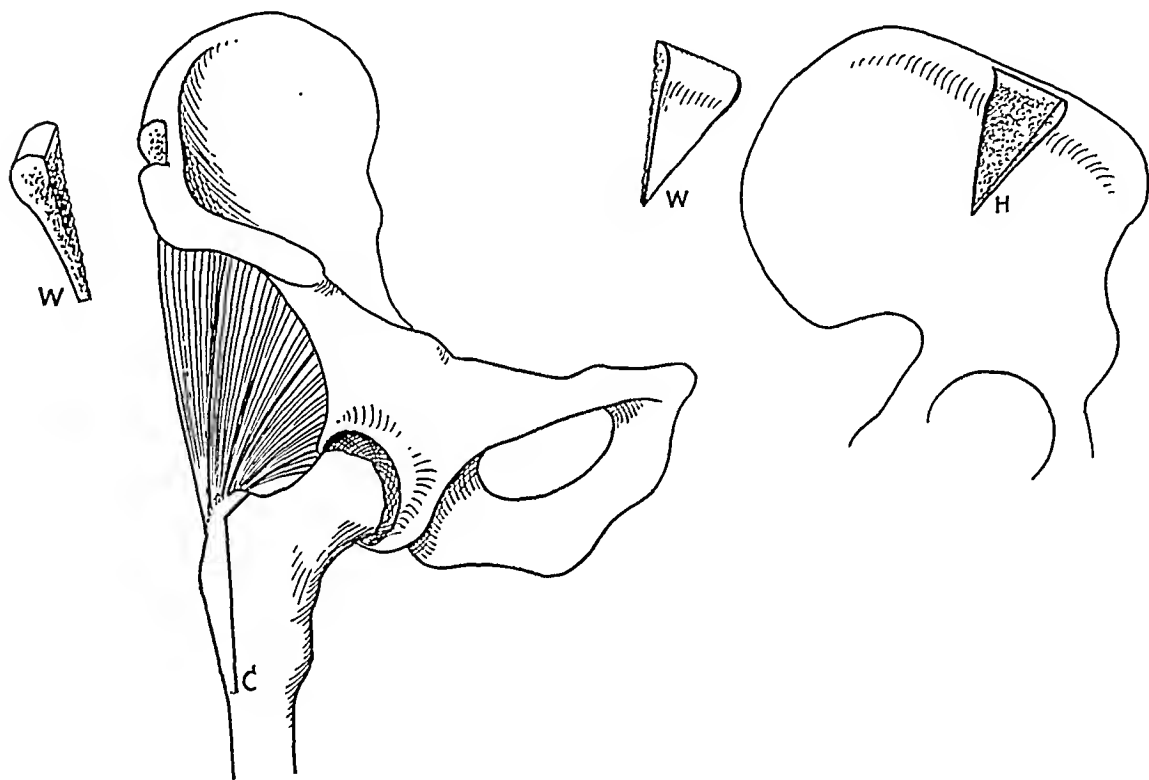


FIG. 1.—Drawing illustrating first steps of operation, showing the lines of proposed bone incisions.

with a well formed acetabulum, containing clear liquid, quite closely resembling synovial fluid. The femoral portion of the hip, however, was merely the stump of the neck. The hip was very relaxed, and could be readily dislocated. The bone muscle lever was erected from the outer and upper end of the femur, precisely as described. In May, 1925, the patient wrote that the hip was strong and had not dislocated, and that she considered the result excellent.

Technic.—The patient should be placed on a fracture orthopedic table. The Smith-Peterson approach affords such satisfactory exposure that it is the incision of choice for all intra-articular operations. The incision begins at a point about four inches below the anterior-superior iliac spine, and is carried along the outer border of the sartorius muscle, upward to the anterior spine and thence backward, following the iliac crest. The gluteal muscles are detached and reflected subperiosteally from the wing of the ilium downward *en masse*, thus giving a wide exposure of the hip joint.

By means of a large carver's or Murphy's gouge, the femur is separated from the pelvis, care being taken to make the bone incision in such a way that a rounded femoral head and a corresponding acetabular cavity are shaped. The acetabulum is not shaped nearly as deeply as formerly, because of the fact that I find the present technic obviates the danger of dislocation, and further that this is a very satisfactory influence in bringing about a greater degree of ultimate motion. The various carver's gouges and chisels are of great service in plastic bone work, especially in arthroplasties. The large variety of cutting edges and curvatures of the chisel or gouge enables the surgeon to select the proper tool for almost any emergency.

After the general contours of the joint are thus blocked out, the surfaces are merely smoothed and transformed into regular spherical convex and con-

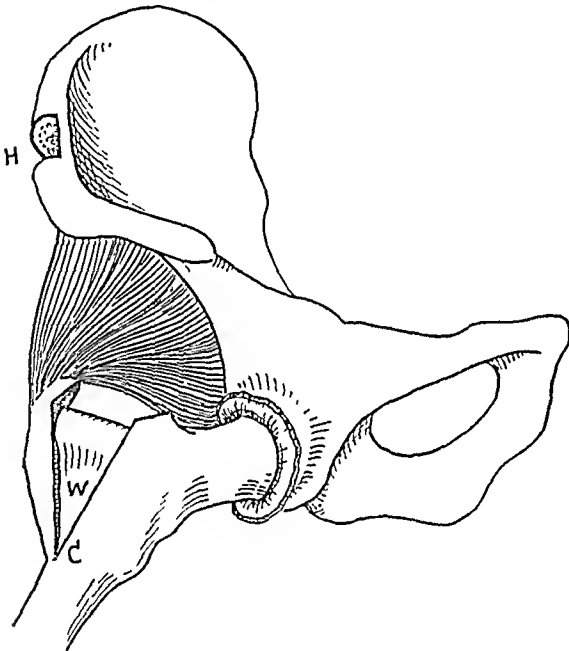


FIG. 2.—Drawing illustrating later steps of operation, with graft (W) obtained from ilium at (H) inserted into triangular space at (C), thus elongating the trochanter-neck lever for weight-bearing and the function of abduction.

cave surfaces by arthroplastic hip rasps, modified from Murphy's. The concave and convex rasps are placed in between the femoral head and the acetabulum and these surfaces smoothed and shaped by a to-and-fro motion of the handle, in the manner of a spoke of a wheel. The tools will execute this work faster if an assistant pushes upward on the patient's knee. These instruments enable the surgeon to shape accurately the inner portion of the joint which cannot be seen or gotten at by an ordinary instrument.

The next step is to apply traction to the limb, to separate the head from the acetabulum, so that the bone particles can be washed

out by means of a glass cannula connected with a fountain of saline solution over the table, and to allow the easy insertion of the fascial flap, about to be obtained from the thigh, lower down. A semicircular skin incision is made on the outer side of the thigh, midway between the hip wound and the knee, and a quadrilateral piece of fascia lata with as much fat as is obtainable, about four inches long by three and one-half inches wide (in adults) is secured. The subcutaneous layer of fat is divided in equal halves, one-half being left attached to the skin, and the other half to the graft, which is subsequently to be removed. With a small curved needle, stay sutures are placed in what are to be the two inner corners, and the fascial graft is drawn in and pushed into the inner confines of the new joint by some instrument as far as possible between the new joint surfaces. Additional sutures are then placed about the periphery of the graft. The fascia is carefully approximated by a continuous suture of No. 1 chromic catgut.

If, at this point, it is thought that the leverage action of the neck of the femur is not sufficient, a bone fragment, consisting of the tip and the outer surface of the trochanter of a varying length (approximately three and one-half inches) is separated with a broad thin osteotome, with the insertion of the abductor muscles intact (Figs. 1 and 2) and swung outward from the shaft of the femur from 20 to 35 degrees, by producing a greenstick fracture at its lower end. Into this triangular space, between the remaining portion of the shaft of the femur and the bone fragment, a segment of the crest and outer table of the ilium is fitted (Figs. 1 and 2). This graft may be supplemented by fragments of cancellous and cortical bone, also obtained from the ilium. This bone-muscle lever operation may be done at the same time as the



FIG. 3.—Roentgen ray of ankylosed hip of eight years' duration, following suppurative arthritis. (Case of L. G.)



FIG. 4.—Roentgen ray of hip (case of L. G.) after arthroplasty. Full range of passive motion of hip. Patient walks very well with cane. Without cane, walks with limp.

arthroplasty, or at a later date, as the surgeon thinks best. The soft parts are approximated by a continuous suture of chromic catgut No. 1. The skin is closed by plain catgut No. 0. Dressings and stickers to the thigh are applied. With the limb in moderate abduction, a plaster of Paris spica is applied from above the costal margins on the opposite side to the toes, with stickers coming out through the plaster, above the ankle. From 15 to 20 pounds of traction with pulley and weight is applied immediately and maintained for three weeks after the removal of the plaster spica (three weeks postoperatively), or until a Taylor traction brace or Thomas knee brace is applied, and locomotion with crutches is allowed.

This brace should be continued for at least three months before weight bearing is permitted, during which time or longer, daily massage and active and passive motion are carried out. Traction is most necessary and should be applied before the patient comes out from under the influence of the anesthetic, because of the devitalization and crushing effect that would otherwise be produced on the fascial graft by the involuntary contraction of the powerful thigh muscles. I have found that with a pulley and rope erected over the bed, fastened to a sling beneath the knee, the patient is able to help very materially in mobilizing the joint by constantly pulling the hip into flexion. This engages the patient's attention, and is a real help as a part of the postoperative physiotherapy.



FIG. 5.—Roentgen ray of hip (case of L. G.) after erection of trochanter lever by means of wedge graft from ilium. Note hip is in abduction, following operation. W indicates graft.



FIG. 6.—Roentgen ray of hip (case of L. G.) two months after second operation, showing adequate lever for function of muscles attached to great trochanter. Patient was able to walk well without cane.

SUMMARY

A ball and socket joint, particularly the hip, with its anatomic provision for muscular control, cannot be stabilized by modeling of the joint contours alone; the fit of a ball and socket joint in machinery may be so accurate as to be within a few microns and still the motion be as free as with a loose fit.

The stability of a freely movable hipjoint, particularly in weight bearing, which is the most important consideration, must be through the medium of muscle control, especially the short trochanteric muscles and their pull upon the trochanter-femoral neck lever. In most arthroplastic procedures, this lever is either shortened to such a degree that it no longer functions, or it may be entirely obliterated. Hence, the necessity for its elongation or restoration by surgical means.

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THE TRAUMATIC KNEE

STATISTICAL SURVEY OF ONE HUNDRED AND FORTY-SIX CASES

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THE economic value of the knee is only realized after injury. Industrially, the knee rivals the back in importance and the diagnosis and treatment of knee injuries are of paramount interest to the working man whose livelihood depends upon its integrity. In the past seven years I have performed 146 major knee operations and a critical review of these cases forms the basis of these observations. Restoration of function and an earning capacity with freedom from pain are, in the final analysis, the crucial points to be considered in determining the value of any given procedure, operative or otherwise. As the series progressed operative procedures were changed to shorten the time of knee joint exposure and particularly to adopt a standard of approach, and a postoperative procedure which would afford the patient the greatest advantage and result in minimal functional defect.

Historically, the knee joint has commanded the interest of surgical generations beginning with the observations of Hippocrates who recorded detailed methods of reducing the dislocated knee. Knee joint history was made by Vesalius, who was the first to recognize that dislocations followed very insignificant accidents which the patient could reduce himself; by Ambrose Paré, who in 1558 removed the first joint mouse; by William Hey, who in 1784 was the first to describe semilunar dislocations; by the Weber Brothers in 1836, who first placed the mechanism of the knee joint on a scientific basis, and by Meyer, who demonstrated the screw mechanism of the condyles and the function of the crucial ligaments. The resurrection of surgical interest was made by Thomas Annandale in 1885 when he sutured the semilunar cartilage. Allingham, Martin and Timbrell Fisher have also made epochal contributions to knee surgery.

ANALYSIS OF 146 KNEE JOINT OPERATIONS

Right knee involved.....	72	Internal.....	81
Left knee involved.....	74	External.....	2
Male.....	140	Transverse.....	45
Female.....	6	Anterior third.....	38
Extensor apparatus.....	18	Middle third.....	4
Quadriceps rupture.....	4	Posterior third.....	3
Fractured patella.....	12	Longitudinal, marginal or "bucket-	
Patellar ligament rupture.....	2	handle".....	38
Semilunar lesions.....	83	Locked.....	6

ANALYSIS OF 146 KNEE JOINT OPERATIONS (*Continued*)

Complications:		Complete tear of anterior crucial liga-	
With partial tears of anterior crucial ligament.....	7	ment.....	4
With associated lesions of the fat pads (Hoffa's disease).....	25	Joint mice.....	12
With osteo-arthritis.....	9	With osteo-arthritis dissecans.....	6
With acute gonorrheal arthritis.....	1	Giant cell sarcoma.....	1
With villous synovitis.....	4	Cyst of semilunar cartilage.....	3
With popliteal ganglion.....	1	Fracture of tibial spine.....	1
Hoffa's disease uncomplicated (one locked).....	5	Fracture of tibial condyles (intra-articular).....	5
		Infection (operative—extra-articular).	1

Several of these cases are worthy of comment: Six cases required reoperation.

CRITIQUE OF THE SIX REOPERATED CASES

(1) E. T. is cited because at the first operation there was failure to recognize a torn crucial ligament when removing an internal semilunar cartilage. At the second operation after several months' disability the collateral ligaments were plicated with complete restoration of function and security.

(2) L. B. came to reoperation eight months after removal of an internal semilunar cartilage with persistent symptoms of intermittent pain and disability caused by a pinched fat pad. This same case was reoperated one year later for a torn internal cartilage of the other knee. Additional fat pads were removed at this operation.

(3) J. V. was operated for the removal of an internal cartilage and a chondral cyst of the external cartilage which had pushed its way through a split in the lateral ligament at its midpoint. He came to reoperation for recurrence of the cyst one year later.

(4) L. G.'s right internal semilunar was removed and nine months later the left was removed for a second accident.

(5) M. D.'s right knee was operated on for the removal of a joint mouse which had detached itself from the internal condyle of the femur. With the persistence of the same symptoms for nearly a year, it was found upon reoperation that a torn semilunar cartilage had been overlooked.

(6) I. S. was a refracture of the patella caused by too vigorous massage before union had become consolidated.

Several other cases are worthy of comment.

L. F.'s synovial membrane was so intensely congested that it was not until after the removal of his torn semilunar that it was learned that he had had a recent gonorrhea. He made an excellent recovery, however, after a prolonged convalescence.

T. M. had his anterior crucial ligament completely torn and both semilunars detached anteriorly. H. G. had a torn anterior crucial ligament and a torn anterior end of the external semilunar cartilage. T. D., five years posttrauma, had a torn anterior crucial, a joint mouse and a bucket-handle internal cartilage. J. P. and L. W., a torn anterior crucial ligament with a foreign body. W. C., an internal semilunar with joint mouse, removal one year later, and M. D.'s joint was blocked in extension by an interposed hypertrophied fat tab.

The one case of giant cell sarcoma was peculiarly pedunculated—an extra-articular mushrooming from the epiphyseal region of the external femoral condyle, the size of a walnut, which had been fractured at the pedicle.

In the cases of 12 joint mice, five had arisen from the cartilaginous surface of the internal, one from the external femoral condyle (osteochondritis dissecans) and another had apparently arisen from the tibial tuberosity.

There were 25 cases of redundant fat pads. Five cases were independent of torn cartilages. In one case the pinching as indicated by the fibrous synovial tips was bilateral and removed by bilateral incisions. In two cases of semilunar cartilage removal it was necessary to reoperate for the neglected removal of fat pads at the first operation. A fat pad caused locking in one case.

In this series there was one infection; this had been extensively laid open through the extracapsular portion of the knee for the repair of the patellar ligament and tissues lateral to it. A large hematoma developed which subsequently became infected.

To recapitulate the observations on this series of 146 cases: There were four errors (failure to recognize two troublesome fat tabs, one cartilage in a joint mouse case and a crucial tear in a cartilage case) and one extra-articular infection. The errors were all corrected by reoperation.

Before the consideration of the traumatic intra-articular lesions, let us briefly comment upon injuries to the extensor apparatus. The same forces and mechanism operate in the lesions of a torn quadriceps, a fractured patella, a ruptured patellar tendon or an avulsed tibial tubercle. It is merely the point of stress involved. Consider this group as an entity. The cardinal symptom of all is a defect in the extensor mechanism. A sesamoid bone is not designed for strength but is a spreader to protect a joint. The fact that the larger percentage of lesions of the extensor apparatus involve the cancellous patella argues its relative weakness in comparison with the distributed strength of the fan-shaped suprapatellar support or the concentrated cable-like arrangement of the infrapatellar tendon.

Fifteen years ago Mrs. C. L., advanced in pregnancy, while descending some steps on a cold morning, reached behind her to gather in her coat belt, and as she bent backward with her weight back center she felt a sudden snapping at both knees and sank to the steps with a tearing sharp pain. Both patellae were simultaneously fractured. Recently my hospital associates repaired a bilateral quadriceps rupture. Bilateral lesions are not rare.

Paradoxically, the essential lesion of a fractured patella is the soft part damage to the lateral vasti muscles. Their approximation is paramount to the security of the repaired patellar fragments and its omission may contribute to functional failure. It is essential to remove the clots from the joint and to mosaic the larger comminuted fragments into place—never remove large fragments.

Controversy still wages as to technic, suture material and postoperative treatment. I have personally obtained good results from the routine use of a wide curvilinear subpatellar incision with complete exposure of the lateral vasti muscles; the removal of joint clots without irrigation; the repair of the soft tissues by heavy kangaroo tendon, mattress fashion; the replacement

and rematching of the comminuted fragments; the use of a single strong kangaroo suture inserted through the drilled upper and lower fragments and a circular case.

I am opposed to making the incision at the line of fracture, irrigation of the joint with saline or ether, use of unabsorbable patellar sutures and untimely preoperative delay. Unless there are patellar abrasions I can see no reason to delay operation seven to ten days. I believe the repair should be made at once. I use a circular case to prevent a damaging postoperative effusion and to protect the sutures. It acts as a buffer against which reaction can end and absorption begin.

The repair of the quadriceps is a matter of interrupted kangaroo mattress sutures but the repair of the patellar tendon is frequently troublesome. In all cases, the suture of the lateral extension is paramount. In a recent patellar tendon repair I varied the technic by splitting the lower half of the patella vertically, inserting the patellar tendon into the slot and securing it by a transverse drill hole impaling the tendon with a kangaroo suture.

One of the most frequent intra-articular lesions is the common "bumper fracture," involving the external tuberosity of the tibia. Depressed fractures of the tuberosities altering the alignment of the articular surfaces of the joint give bad after-results unless the alignment be reestablished by open or closed correction. Manipulation and moulding may realign the gliding surfaces but if the check-up plates are not satisfactory, by all means consider operation imperative. Bearing in mind the neurologic anatomy of the lateral aspect of the joint, the depressed tuberosity can easily be pried up and pushed or hammered into normal alignment. The procedure is simple, effective and essential for function.

There are certain anatomic requisites necessary to the understanding of the mechanism of semilunar damage:

(1) The anatomic balance of the knee is an engineering triumph—designed, however, for all stresses but torsion.

(2) Mechanically, the joint has a three point suspension—hung, as it were, anteriorly by the quadriceps, postero-internally by the semimembranosus, postero-externally by the biceps tendon. These points are reinforced medially by the strong internal lateral ligament, the tendons of the gracilis, semitendinosus and the sartorius, and externally by two strong collateral ligaments. These muscles pull the leg upward against the head of the femur, while as a counter pull, the popliteus and the two heads of the gastrocnemii posteriorly secure the femoral condyles against the tibial tuberosities. This muscle tripod, the lateral and capsular ligaments, secure the joint externally whereas internally the crucial ligaments lend strength, but only for anteroposterior stress, and the semilunar walls tend to prevent lateral displacement.

(3) The strength of the joint is paradoxically dependent upon and commensurate with the strength of the thigh and calf muscles. That sense of "knee weakness" is felt by those with atrophic muscle changes with the resulting loss of the "counter pull." The knee, then, reaches maximum strength

in extension and is weakest in flexion, when the counter pull is relaxed. Most traumatic lesions, therefore, occur with the knee in partial flexion.

(4) The sheering action of torsion lesions occurs only on the anterior part of the joint because the body weight assists in tearing or breaking the anterior knee mechanism when in partial flexion. The flexors, wherever situated, are always more powerful than the extensors and moreover the anterior portion has no femur-to-leg pull such as the strong down pull by the gastrocnemii posteriorly. This accounts for the predominance of stress damage to the extensor apparatus and the absence of posterior knee lesions.

(5) The displacement of the anterior end of the internal semilunar cartilage is accomplished by an inward rotation of the femur with the foot fixed or inward rotation of the leg and foot with femoral fixation; whereas the external semilunar cartilage is displaced by the outward rotation with the foot fixed or outward rotation of the foot with the femur fixed. Abduction and flexion of the knee are essential with torsion. The mechanism which accounts for the greater percentage of semilunar tears is an inward twist of the femur when the knee is flexed, the leg abducted and the foot fixed—or its converse, a twist of the foot with the thigh fixed. Arising from the squatting position has given the condition the name of "miner's disease." Martin found 62.8 per cent of his cases among miners and 18 per cent among football players.

(6) In Martin's series 92 per cent were the internal cartilage, Henderson's 94 out of 98, and in the past seven years I have had but two cases of external cartilage damage in 83. The relative freedom of the external cartilage to injury is explained by (1) the fact that the internal cartilage is firmly attached to the internal lateral ligament in its posterior half whereas the external lateral ligament is freely movable over it, and (2) the external semilunar cartilage is more movable and adaptable, (3) the anterior horn of the internal semilunar cartilage is relatively less firmly secured to the upper surface of the tibia and (4) the internal cartilage is more exposed to the sheering violence as it is C-shaped, whereas the external cartilage is almost circular and does not therefore resist torsion.

(7) Thirty-eight of the 83 cases herein reported were of the bucket-handle type in which there is a longitudinal splitting or marginal separation with displacement of the cartilage wholly or in part into the intercondylar space. The mechanism of this type is explained by Fisher as a result of a more severe rotatory movement in which the internal lateral ligament is torn from its cartilaginous attachment and if abduction be a marked feature of the case, the midportion of the cartilage slips into the interior of the joint and when extension occurs the cartilage is split longitudinally when the condyle of the femur is jammed down upon it, producing a typical "bucket-handle" lesion. In his series the longitudinal type predominated—38 per cent.

(8) The early changes in the joint are extravasation of blood in varying amounts, synovial effusion, followed later in neglected cases by thickening of the capsular ligament, circulatory changes in the articular cartilages with

granulation tissue spreading in from the osteochondral margins and atrophy of the quadriceps group. Finally, cartilages may become eroded or destroyed, the fat tabs become enlarged and edematous, villous papillae begin to appear and the joint terminates in arthritis and hypertrophic osteo-arthritis.

Etiologically, the condition is found at all ages, especially in muscular types, rarely in women, rarely by direct violence, and rarely is the external cartilage involved, indicating that internal wrenching with flexion of the knee, abduction of the leg, and fixation of the foot is the prevailing causal mechanism.

When the essential torsi-flexion mechanism has been executed there follows a sequence of symptomatic events which are initiated by pain, followed immediately by muscle spasm, and if the muscle spasm begins before the knee has, as it were, untwisted itself and the cartilage disengaged, the cartilage becomes damaged and the knee locks at once. Not infrequently the patient maneuvers the leg himself and frequently he will describe snapping it into place. The click may be audible. Many cases are immediately locked and remain so until the time of operation. I recall three instances in which a knee was unlocked, so to speak, upon administration of spinal anesthesia.

Effusion or pain is conducive to limited motion. Gradually as the fluid and the pain subside, motion is restored until at a later date the locking episode occurs again with the return of the same symptom complex. Locking of the joint is not essential for a diagnosis. In my experience I would estimate one-third of the cases gave no history of locking.

One must make careful inquiry as to just what the patient means by locking. I have so many times been convinced that a given joint did not "lock" but upon analysis there was merely a clicking sensation. When the joint is locked it is fixed in extension—rarely in flexion. It has been my experience that the so called blocking mechanism occurs in cases of transverse laceration of the cartilage at about the anterior third with doubling up of the anterior fragment; or in such cases of longitudinal splitting wherein the inner condyle of the femur has, as it were, buttonholed itself through; and in this manner extension is made impossible.

Not infrequently one can diagnose some of the types of laceration by the history. It has been my experience that complete transverse fractures usually lock the joint by buckling up in front of the condyle of the femur and preventing complete extension. Many of the bucket-handle type or longitudinal splitting are those which lock the joint at frequent intervals, sometimes as frequently as five or six times a day. The inner portion of the cartilage splits longitudinally or marginally, does not become detached at the ends but shifts from its normal position at the outer margin of the condyle back and forth into the intercondylar space and the joint is never totally locked or blocked except when the longitudinal splitting extends to the very anterior attachment. The crushing at the midportion wherein there is an incomplete fracture rarely, if ever, locks but gives continued pain, partial disability and intermittent periods of effusion. The point of tenderness is on the lateral side of the joint and is very well localized. In the circumferential type, after the initial locking,

the joint rarely locks again, but this type of knee is a prolonged source of pain and partial disability. Tenderness extends from the anterior end far back laterally. Locking does not occur unless the cartilage becomes dislocated into the intercondylar space.

Upon examination there may or may not be effusion into the joint. In the early stages effusion is the rule. The joint rarely crepitates upon manipulation but there is a varying degree of limited motion depending upon whether the joint is locked and whether the case is early or late. In the neglected cases there is a resultant disuse atrophy particularly involving the extensor group of muscles. There develops an interstitial myositis with fibrous contractural changes which prevent complete flexion. In these cases wherein the atrophy is noticeable there is always a limitation of from 10 to 45 degrees of motion. This interstitial myositis is due to disuse, apprehension of the painful recurrence of the locking episode and in many instances or, shall we say in most instances, to the various forms of supporting kneelets or elastic bandages which are at times unfortunately applied to tourniquet constriction.

In the interval between the locking episodes, the knee joint is frequently not painful and many patients will tell you that straight line walking, mounting stairs, *etc.*, is painless but as soon as the toe is stubbed and the foot twisted sharply inward or outward they get sharp pain referred in all instances just lateral to the lower patellar pole. The lower pole of the patella is the landmark of the articular junction between the tibia and femur. Just lateral to this is the point of attachment of the anterior end of the cartilages and point tenderness is one of the essentials of the diagnosis. Tenderness may extend as far back as the midquadrant. Continuous line tenderness is suggestive of a splitting of the cartilage from its coronary ligament attachment whereas the tenderness midway back is suggestive of the transverse type of fracture, complete or incomplete.

Not infrequently, with the knee in complete extension, there is in the bucket-handle type a dimpling in along the anterolateral margin of the knee due to the intercondylar displacement of the meniscus. Not infrequently a loose fragment in thin individuals is palpable over the anterior end of the internal semilunar cartilage and the small mass has often been pointed out by the patient himself. One should be satisfied, however, to make the diagnosis of a torn cartilage without attempting to differentiate the pathologic type. It is amazing, however, in seeing a large number of these cases to learn how comparatively accurate one may become in differentiating the varying pathologic varieties.

Effusion is a protective biologic reaction which separates the damaged parts, and at the same time, by the distention of the joint, it is immobilized in semiflexion. By distention, a joint sometimes becomes unlocked due to separation of the articular surfaces, permitting the fibro-elastic cartilage to snap back into place with relief of pain and muscle spasm. The aspiration of a joint in many respects, therefore, is unphysiologic and the reduction in volume

were better handled by external pressure rather than the sudden withdrawal of the fluid which is in nearly every instance followed by a reaccumulation.

Atrophy is not a symptom; it is a sequela. As previously related it is due to disuse and too long continued circular compression by elastic knee supports or unduly tight bandages. As time progresses atrophic changes increase and sooner or later an interstitial replacement fibrosis ensues which greatly, and may permanently, impair motion. It is for this reason that early operation is indicated, and it is for this reason that many disappointingly high percentage losses are encountered when operation has been deferred too long. Cases in which atrophy exists with marked restriction in flexion should be given a preoperative manipulation to overcome, if possible, the fibrosis. Above all, active exercise is encouraged to maintain muscle tone and joint security.

In the diagnosis of the case, therefore, a very careful history should be taken in which the patient should describe in intimate detail the onset of the identical mechanism which produced the sudden pain. The history is one of the essentials of the diagnosis. There are other pathologic conditions which may cause locking of the joint and a radiograph is always essential to exclude mechanical obstruction. While locking of a joint is suggestive of internal derangement it is absent in at least one-third of the cases. Tenderness localized over the torn cartilage, a varying degree of restriction of motion, fluid, and atrophy complete the picture. The essentials, therefore, are the history of sudden torsi-flexion violence followed by pain and effusion with or without locking of a joint, marked tenderness at the point of the lesion, lack of response to physiotherapy, and, in late cases, a flexion defect due to atrophy.

Pneumo-arthritis with oxygen, nitrogen, or carbon dioxide has been discarded as being of insufficient diagnostic value.

Never fail to have comparative radiographs made. I have compared films with operative findings and am thoroughly convinced of the fallacy of a radiographic diagnosis of a torn cartilage. The diminution of the space between the condyle and tuberosity is not pathognomonic of the lesion and obviously so because the cartilages merely act as packing agents or a filler for the triangular chink between the outer joint margins circumferentially, and are not interposed between the two bones.

By placing the roentgen ray tube in various positions we can change the spacing between the two opposing osseous femoral and tibial bodies. I have demonstrated on numerous occasions a diminution of the joint space in the nontraumatic and normal knee. The radiographer can contribute in assisting in the diagnosis with the exception that a so called negative film is what is to be looked for to differentiate in the diagnosis as against such locking as might be produced by a foreign body. The roentgen ray, therefore, is essential not in the diagnosis but in the differential diagnosis, except in the neglected case where the cartilage may undergo some slight calcific change, to be detected along its margins.

The radiographs in suspected knee lesions must be critically searched in making the differential diagnosis. The margins of the femoral condyles should

be closely scanned for irregularities as are seen in osteo-arthritis dissecans which so frequently form the nest of the joint mouse. Foreign bodies of the osteochondral type should be looked for. The varying hamstring sesamoids should be excluded as intra-articular by their margins and contour, but may I state again a torn internal semilunar cartilage with but one exception gives a negative film. I had occasion not so long ago to observe a knee locked in extension. As soon as the patient was given a spinal anesthetic the knee could be freely put into complete extension after the muscles had been relaxed. Upon opening the joint I found the joint space had been widened fully an eighth of an inch by the interposed doubled up cartilage and upon review of the films again after operation I found the joint space between the femur and tibia on its internal side was greater than on the external side. An increase but certainly not a diminution in the joint space, therefore, may be of some diagnostic value.

A point of diagnostic interest is to place tension upon the torn cartilage in the following manner. While the patient is sitting on the examining table with his extremity at 180 degree extension, flex the knee slightly to relax the muscles and fix it firmly against your own body. With the other hand grasp the foot and gently rotate the leg inward. Pain is noted at the attachment of the anterior end of the external semilunar cartilage, if the lesion is there. Then, rotate the leg outward, putting tension on the fibers of the internal semilunar cartilage and by overstretching the fibers, if torn, the pain will be greatly aggravated.

In the differential diagnosis one ought readily to exclude a tear in the internal lateral ligament—rarely complicated by fluid, never locked, tenderness localized on the medial surface, usually, and increased by tension on the ligament—namely, abduction at the knee while the leg is in extension.

The locking due to foreign body can at times be palpated and readily excluded radiographically.

Diagnostically, then, we are left with but three other conditions—osteo-arthritis dissecans, a pinched fat tab, first described by Alfred Hoffa, and the torn crucial ligaments.

In the former condition a very critical review of the radiographic contours of the internal and external condyles of the femur will be sufficient to make the diagnosis. In these cases clinically the point of tenderness is close to the patella on the condylar surfaces of the femur; whereas in semilunar cartilage damage tenderness is at its attachment along the margin of the tibial tuberosities and in Hoffa's disease the tenderness is just lateral to the patellar tendon so that we have points of tenderness in these three conditions mentioned, respectively forming a triangle with the tenderness above in the dissecans pathology, tenderness below and to the outer side in meniscus damage, and tenderness internally and below in the fat tab syndrome.

The differential diagnosis of the fat tab, Hoffa's disease, as it is sometimes called, is made by exclusion. I believe the mechanism in this case is due in most instances to direct violence with a hemorrhage inside the capsule

and subsequent edematous changes in these two folds of fatty tissue which lie beside the alar ligament just internal to the anterior attachment of the semilunar cartilages and immediately lateral to the patellar ligament. When this fatty tissue becomes traumatized, usually by direct violence, the traumatic reaction puffs out these fatty festoons and with the sudden extension of the leg there occurs a sharp pain of a pinching type. It does not cause locking, but a sudden muscular spasm occurs to fix the joint in order to prevent further pain. This leads many patients to describe the episode as locking, whereas it is essentially a pinching plus a muscle spasm. As previously pointed out the tenderness is close to the patellar ligament and not proximal to the femoral condyle nor the meniscus attachment. Moreover, the pinching episode does not come on at the time of the initial violence but at a later date and only comes on in complete extension when the fatty tissue is relaxed and, as it were, gets caught between the tibia and femur. The locking episode is essentially a fixation from pain and not a mechanical blocking such as we get in cartilage derangement. Pathologically the fatty festoons become fibrous from repeated pinchings. In many instances the symptom complex can be differentiated from that of the torn cartilage.

The rupture of the crucial ligament is associated with severe violence and is followed by hemarthrosis and rapid effusion. Semilunar pathology may coexist. The test for a torn anterior crucial ligament is the so called "drawer sign" in which, seated before the patient, with his knee at 90 degrees the leg can be pulled forward by the examiner or can be abnormally hyperextended or rotated; whereas when the posterior crucial is torn, the leg can be pushed backward when the knee is at 90 degrees.

The prognosis depends upon the time elapsed between accident and operation, age of patient and whether or not osteo-arthritis, arthritic or atrophic changes have developed. The average early case should obtain a favorable recovery without limitation of motion. The late cases with coexisting pathology and atrophy will have a percentage residual limitation, which, however, should never exceed the preoperative restriction. Cartilage removal will not overcome arthritic or osteo-arthritis changes nor will it improve muscle atrophy if dependent on organic muscle fibrosis, although definite benefit will be obtained by removal of the offending cartilage regardless of other existing pathology. The prognosis also depends upon whether the associated pathology will have been corrected at the time of operation. Failure to remove all the foreign bodies, pinched fat tabs, failure to recognize torn crucials or the "other" torn meniscus—all contribute to a poor prognosis.

With, however, early operation, in the absence of quadriceps atrophy, the employment of a small incision, and minimal operative insult, a lasting benefit without functional defect should be obtained. Temporary disability from six to ten weeks is the rule.

What, therefore, is the indication for operation?—the diagnosis. There is one rational treatment for a torn cartilage—its removal, and this, as soon as the diagnosis can be made. I have operated in emergency on a few cases

brought into my office or the hospital with the joint locked. If, however, there is no locking and we are still confident of the diagnosis I think it might be well to wait a few days for the subsidence of the synovial reaction. This, though, is by no means essential. The joint should be put at rest, but in my opinion external heat, manipulation, diathermy and all forms of physiotherapy are contraindicated.

A majority of the cases which were encountered were those which had been subjected to physiotherapeutic insults for weeks and sometimes months. These are the cases which bleed profusely. I have found repeatedly no necessity for ligatures. The region of the knee joint does not take kindly to the foreign protein of catgut.

After performing any series of routine operations one unconsciously drifts toward simplicity of method and economy of maneuver and manipulation. I have arrived at a standard of operation which is recommended in view of the short time obligation imposed upon the working man and the very low percentage loss motion. I have followed most of my cases back again to industry. The majority have minimal defects. Many have no defects. The higher percentage defects are due to the long delay in operations in which there has been replacement fibrosis in the quadriceps muscle preventing complete flexion and other associated pathology. This delay is not to be accredited to the operative procedure but in many instances to prolonged physiotherapy.

The incisional approach so frequently spells the success or failure of the arthrotomy that observation in these cases may be of interest. In the early series we opened the joint vertically by splitting the patella, or the long parapatellar exposure, curved or straight, but in so many cases we had difficulties that we were forced to abandon these pedigogic or teaching exposures to obtain freer postoperative mobility and a shorter period of convalescence.

A certain number of cases develop an unusual postoperative effusion. In two classical instances of my colleagues, in which nine-inch parapatellar incisions were made, postoperative intra-articular pressure ruptured the capsular and ligamentous sutures, permitting a complete external dislocation of the patella—both cases came to reoperation. Another group of cases present a postoperative subcutaneous periarticular reaction due to lack of resistance to the excessive amount of catgut required in such long incisions. This periarticular reaction subsides very slowly and greatly prolongs a convalescence. Longshoremen, demolishers, construction and cement workers and other types of labor in which the foreign element forms a very high percentage, will frequently develop a psychoneurotic attitude to the long scar and its frequent periarticular reaction which gives them adequate pretext to prolong compensation payments for a year or more. Moreover, the frequency of sensory disturbances, particularly the numbness following severed internal saphenous nerve filaments, is another pretext for prolonging disability payments.

The knee joint is therefore less exposed to surgical insult by the use of the "peep-hole" incision—one inch long, extending below and lateral to the patella, terminating at the anterior end of the semilunar attachment. After

the skin is incised the subcutaneous tissues are forced bluntly aside, the collateral ligament exposed and split in the direction of its fibers and again by blunt dissection the capsule exposed. At the lower pole of the incision are the geniculate arterial twigs which can be retracted, with a bloodless access to the joint. The one-inch capsular incision can be stretched by blunt retractors to permit visual access to all the structures of the anterior portion of the joint where practically all of the joint pathology lies.

In semilunar pathology, clinical signs will indicate whether it be a dislocation of the internal or external cartilage and the incision can be made accordingly. All pathology can be treated through the small incision except the removal of the opposite semilunar. With the cautious and gentle use of the blunt retractors there is no necessity for overlooking additional items of pathology. The teaching incisions have been abandoned as being unnecessary, exposing the knee to hazardous complications, and contributing in many cases to unstable joints. A procedure is presented and recommended, which for simplicity may be indicated by the following points in technic:

(1) Preoperative shave; green soap scrubbing, iodine, decolorized with alcohol and a sterile towel.

(2) Morphine, preliminary to spinal anesthesia, for complete muscular relaxation and vasomotor constriction.

(3) Omit the tourniquet.

(4) Iodine preparation from the toes to the upper thigh. We do not consider the operative technic of entering the knee joint with any more apprehension than a laparotomy. We omit the Lane, no touch technic, and avoid towel tricks. We believe the knee has the same biologic resistance to infection as the abdomen and will take care of the casual staphylococcus present in any operative skin incision.

(5) With this preparation not one of this series had an infectious reaction, though a few had an escape of synovial fluid into the subcutaneous tissues, another small number showed catgut irritation, and one or two cases had stitch abscesses. In no case was there a septic arthritis. As proof of the preparation there has been the primary healing.

(6) Just lateral to the patella, beginning at the anterior end of the semilunar cartilage, a vertical one-inch incision is made. This skin knife is discarded, and by blunt dissection the internal lateral ligament is exposed. This is split in the direction of its fibers and at the lower end of the split is encountered the inferior geniculate artery which is the only ligation required, and in many cases this can be retracted. The capsule is then divided and blunt fenestrated McBurney's retractors are inserted and the entire wound inspected, without traumatizing the synovial membranes.

(7) Through this opening it is possible by the proper application of blunt retraction to inspect the opposite cartilage, anterior crucial ligament, fat tabs, condyles of the femur and the semilunar cartilage.

(8) We use the standard abdominal technic, have discarded the no touch method, and do not traumatize the synovial lining.

(9) In the transverse fractures, the anterior fragment is removed *in toto* by the use of a bistoury pointed scalpel. In cases which have not been subjected to prolonged baking and diathermy there is very little vascular reaction when the margin of the cartilage is split from its attachment at the coronary ligament. Gauze packing for a moment or two is a sufficient hemostat. In the bucket-handle type the inner fragment is cut by a narrow, sharp pointed blade as far back in the intercondylar space as possible. Then the external portion is removed from the margin of the tibia as far back as possible. I have never encountered postoperative symptoms from the retracted posterior cartilage fragment.

(10) Take scrupulous care to cut off the snow capped tip of the fat tabs. This was brought home to me in one or two classical cases in which a very satisfactory removal of an internal semilunar cartilage was done and some months later it was necessary to reoperate to remove two fibrous fat tabs before a cure of symptoms could be obtained. This impresses one of the necessity of removing all the pathology of a knee in one sitting.

(11) The fat tabs are trimmed off, rarely tied. The bleeding is insignificant and stops readily on pressure.

(12) Use the gentlest intra-articular manipulation.

(13) The joint should not be closed until all bleeding points have been stopped by pressure.

(14) We protest against pouring saline or ether into the knee joint.

(15) Closure of the wound consists of the use of single No. 2 chromic, interrupted, with exact apposition of the synovial borders without eversion of the synovial membrane into the extra-articular spaces. Interrupted sutures are used, as not infrequently there is a pronounced postoperative effusion which sometimes persists for many days. If a single continuous suture be used it not infrequently absorbs or breaks and the entire capsule wound gaps open. The same may be said in repair of the internal lateral ligament, namely, the use of single, interrupted chromic No. 2 at quarter inch intervals. The repair of the subcutaneous tissue should be made by plain No. 1, either continuous or interrupted, and use of silk for skin is preferable to catgut as the latter not infrequently produces an aseptic reaction. One small square of gauze is placed over the wound and the single layer of wadding is rolled around from the midcalf to the midthigh. Around this a circular case is applied. The case is used as a buffer to prevent an undue effusion into the joint and to avoid the danger of too much tension on the sutures.

(16) The case is removed on the fourth day and the wound inspected. The sutures are removed on the seventh day and gentle passive motion begun. I do not approve of forceful, painful flexion of the leg at this time. Let the patient be his own masseur and manipulator—but keep after him! On the fourteenth day the patient routinely leaves the hospital, usually encumbered with a little excess fluid which subsides in the course of an additional two weeks. Persistent activity on the part of the patient is encour-

aged and manipulation and massage is necessary only in the case with muscle atrophy. Six to ten weeks is an average disability.

SUMMARY

- (1) Early diagnostic recognition of the torn cartilage and its differentiation from other conditions.
- (2) The diagnosis is the indication for operation.
- (3) The contraindication of physiotherapy after injury and the tourniquet prior to operation.
- (4) The employment of the small, bloodless incision and the gentle handling of the intra-articular structures.
- (5) Early postoperative muscle development.
- (6) The minimal scheduled defect and the short postoperative convalescence recommend the standardization of this method of treatment.

INTERNAL DERANGEMENTS OF THE KNEE *

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WHEN a patient complains that his knee slips, catches, locks or gives way, it is no longer wise to make a diagnosis of a loose meniscus, and take it out through a peep-hole incision. There are other conditions which are involved in these attacks of instability, pain and swelling which should be considered and attended to.

The stability and usefulness of the knee joint can be interfered with in more ways than one. It is better not only to make as careful a preoperative diagnosis as possible, but also to make as thorough an exploration as can be done without impairing the joint function. The synovial lining and its subjacent fat pads, the articular cartilage covering the femur, patella and tibia, the lateral and crucial ligaments must be considered as well as the meniscus on each side. In addition to these conditions, loose bodies in the joint and abnormalities in the periarticular structures should be borne in mind.

If a naked femur and a tibia are fitted together, one is impressed by the poor fit of the articular surfaces. With the menisci in place, the cup for the condyles on each side is a little deeper but it still looks pretty unstable. When the collateral and cruciate ligaments are added, it gains a good deal of rigidity. But clinically the knee is only rigid in two positions, extreme extension (the locked position) and extreme flexion. These ligaments are all lax in any other position as can be shown by the distinct amount of rotation and lateral motion which can be obtained in any normal knee if the muscles are relaxed. If it is realized that the only time, in normal use, that the knee is fully extended is when the individual stands with his weight on one leg, the importance of these ligaments in maintaining stability becomes negligible. They check excessive motion but they do not hold the knee rigid. In ordinary walking, running, lifting, sitting or in the various forms of athletic exercise, the knee is never in complete extension or complete flexion. The stability and smooth function of the normal knee depend on the supporting muscles which pass across it. Hence, the importance of maintaining the tone of these muscles when the joint becomes deranged. As the knee is flexed and extended, the point of contact between femur and tibia shifts forward and backward. Coincident with this the menisci move forward and back. This probably is due to the pressure of the approaching articular surfaces in the same way that a watermelon seed can be propelled when squeezed between thumb and finger. Unless the pressure is maintained steadily, however, they can be caught between the opposing surfaces and then become subject to crushing injuries, which split, break or loosen their attachments.

In certain parts of the knee joint, the synovial lining is firmly adherent to

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the adjacent periosteum, capsule or aponeurotic structures. Elsewhere it is separated by fat pads of varying thickness. Distal to the patella this fat pad is more marked than anywhere else and its synovial covering lies in folds with thin sharp edges which lie more or less horizontally. It is attached to the anterior part of the intercondyloid notch by a thin band called the ligamentum mucosum. These synovial folds or alar ligaments can be caught between the joint surfaces with resulting hemorrhage and laceration. With the organization of the blood clot, fibrous nodules are formed which in turn are more easily caught and again damaged. Several of these fibrous nodules may be found in the free edge, sometimes of considerable size, and may even contain bony tissue. At times these nodules are seen attached by thin pedicles and they may become detached to form one type of loose body.

Less frequently the fat pads lying elsewhere in the joint are hypertrophied with resultant folds and fringes or villi. When sufficiently pronounced, it is called villus arthritis. The term lipoma aborescens, has been used to describe an especially exaggerated type with cauliflower like mass of deep yellow or orange colored fat.

The pad lying just proximal to the patella between the quadriceps tendon and joint cavity may hang down and get between the patella and femoral surface. Similar fat tabs are found lateral to the femoral condyles. These have been seen hemorrhagic and lacerated.

There is a wide variation in the appearance of the synovial lining in these deranged knees. It may be quite normal in appearance and texture, often it is injected, frequently it is thickened, edematous, velvety and purplish in color, or it may have a deeper sepia color. In recent cases of injury, actual lacerations of the synovial lining are seen. In old cases with repeated accidents, especially when loose bodies are present, it may be brown, tough and leathery and two to five Mm. thick. Adhesions are found at times, either in the form of bands or as partial obliteration of a portion of the joint cavity. These undoubtedly give rise to pain and limitation of motion.

The articular cartilage covering the femoral and tibial condyles and the back of the patella frequently shows evidence of disease. Instead of the bluish white appearance and hard surface it may be distinctly yellow and soft. When a smooth instrument is rubbed over its surface, it feels loosened and can be thrown into little folds. The cartilage may be fissured and frayed so that finger-like processes can be lifted up. The process may go deeper and involve almost the whole depth of the cartilage and large portions may be partly detached with the formation of pedunculated flaps. The more exaggerated picture where large areas several cm. in diameter are more or less completely separated with a portion of underlying bone is less commonly seen. It is believed that only this extreme type deserves the title of osteochondritis dissecans. Chondritis seems a better term for what may be the early stages of the same condition. This condition can quite well be explained by trauma alone, without making use of the embolic theory. The milder lesions are frequently associated with an abnormal meniscus, fat tabs

and loose bodies, or they may be the only discoverable lesion. When these portions of articular cartilage become entirely separated they form a second type of loose body. A third type of loose body is seen when a portion of the condylar surface is knocked off by direct trauma. Sometimes its former site appears as a concavity in the condyle, the surface of which varies with the time elapsed since the accident. In several cases with rather recent accidents, masses of fibrin were found lying on and adherent to the synovial lining. In one case a strand was found, six cm. in length and attached only at its two ends. These easily might have become detached to form loose bodies.

Seventy-nine per cent of our cases gave a definite history of injury to the knee which usually involved side bending or rotation. It is quite logical to suppose that most meniscus cases start with such an injury which loosens their normal attachment and makes them more likely to become pinched and injured. When such knees are explored soon after the injury, it is often possible to demonstrate tears in the aponeurotic layer, in the lateral ligaments, in the synovial layer and the patellar tendon. In our last 109 cases, 18 per cent showed partial or complete tears of the anterior cruciate ligament and many of these had no instability demonstrable.

The various types of injury to the meniscus are well known. It may become detached at any point in its circumference and split in any direction, or it may only be abnormally loose. In any case it gets caught between the condylar surface and makes trouble. Cysts occur occasionally in the cartilage. We have but one suspected case which refused operation. Occasional new growths are found in the periarticular structures which may interfere with normal joint motion. We had one example of hemangioma invading the region of the knee which had extended into the alar fat pad and become injured. In a number of these cases hypertrophic lipping of the margins of the femoral or patellar articular surface was found. These irregular spurs may be smooth and rounded or may present sharp, jagged edges. The synovial membrane in contact with these projections shows the evidence of repeated irritation. Irregularities in the articular surfaces of either femoral condyle, or tibia, or the dorsal surface of the patella as a result of fracture, sometimes interfere with normal joint function.

The histories of patients with internal derangements of the knee are very similar irrespective of the condition existing in the joint. There are usually repeated attacks of what they describe as slipping, catching, giving way, or locking of the knee, usually accompanied by a sudden, sharp pain and followed by more or less joint swelling. The attacks may be slight in severity and transient in duration, relieved by shaking the leg or kicking it out straight. On the other hand, the joint may be definitely locked with inability to change the position which persists for several days. Some people are able to discover just what motions bring these attacks on and learn to avoid them. One patient is recalled who gave up, one after the other, tennis, golf, swimming and running, but when her knee locked as she turned over in bed, she

not sufficient to justify the exploration. In no case was the knee completely normal.

SUMMARY

The meniscus is not the only cause of internal derangement of the knee. Many other conditions may give the same clinical picture.

The majority of these knees have more than one lesion.

It is wiser to make an incision which will allow full exploration of at least the anterior portion of the joint.

The thigh muscles are the most important structures in maintaining stability of the knee joint. Maintenance of their tone should be aimed at before operation and resumed as quickly as possible afterwards. This is best accomplished by active use.

ILLUSTRATIVE CASE REPORTS

CASE I.—P. F., 19 years of age. Three and one-half years before admission, the patient jumped down a short distance, kicking his heels up as he did so. Before he reached the ground, he felt a sharp, sudden pain in his right knee. After that, he was unable to put his heel to the ground in walking; that is, there was distinct limitation of extension. Operation was advised but refused, and the patient continued to have an unstable, weak knee.

Three days before admission, while climbing stairs, something snapped in his knee and he was unable to extend it beyond 130°. There were pain and tenderness along the medial aspect of his joint line. He was operated on May 25, 1932, and a "bucket-handle" meniscus was excised. The synovial lining was slightly thickened, but the articular surfaces and other joint structures were normal. He was up on the fourth day, walking on the sixth, and discharged on the eighth. He reported back five months later with a complete return of function and with no pain or disability. He stated that on the fourteenth day after his operation he pitched a full nine innings of baseball and ran bases, too, without subsequent pain or swelling. Two years and three months after his operation he is still rated as completely normal.

CASE II.—S. D., 20 years of age. Ten days before his admission to the hospital, the patient slipped while working and struck the inner side of his left knee. There was immediate pain, followed soon by swelling. There was limitation of extension with tenderness along the medial aspect of the joint line. Seventy-five cc. of bloody fluid were aspirated and, on the following day, 50 cc. more. As extension was still limited after 12 days, he was admitted for operation which was carried out April 11, 1933.

The joint contained about 30 cc. of serosanguinous fluid. The medial meniscus was partly detached in front, thickened and split, the inner portion being loose and tucked under the lateral portion so that its end was presented as a rounded nub. The ligamentum mucosum and the anterior cruciate ligament were completely torn across. The meniscus and stump of the cruciate were excised and the alar pad sewed up to the front of the joint.

The patient walked with crutches on his ninth day and was discharged on the tenth. At the end of five weeks, he was playing box ball. At three and one-half months his only complaint was slight pain on the inner aspect of his joint. He went back to work in the boiler room at the end of three months. At the end of a year, there was no instability or pain. His movements are complete, but he says that after long walks or playing baseball, he has a slight sense of weakness.

CASE III.—A. H., 40 years of age. Ten years before his admission to the hospital, a horse fell on his leg, which laid him up for a month. The pain, which began at that

time, increased with gradual swelling three weeks before his first admission and roentgen rays showed the presence of a loose body.

On July 10, 1931, at operation, a pedunculated, loose body was found in the intercondyloid notch, and removed through a small incision. The patient started weight bearing on the tenth day and was discharged on the twelfth. He continued to have some pain and a sense of weakness, with a varying amount of fluid in his joint.

Twenty-one months later he had to give up work because of pain and swelling. He was readmitted May 2, 1933. The knee was explored through a longer incision. There were many large hypertrophic spurs along the articular margins of the condyle and patella. The medial meniscus was eroded and the synovia was thickened, purplish and fringed, and the alar fat pad was hypertrophied. The lateral meniscus showed a dentate edge and there was a large eroded area on the femoral condyle. The spurs were removed, and the alar fat pad and lateral meniscus were excised. The eroded area on the condyle was shaved to normal tissue and the greater part of the thickened synovia was excised. The patient could lift his heel from the bed on his fourth day and was up in a chair on the eleventh, walking on the twelfth. A moderate sized hematoma was opened on the fifteenth day which healed slowly without infection, the patient being discharged on the forty-first day. Twelve weeks later his motions were 175° – 90° and he was walking four or five blocks. Seven months after the operation, he reported back that he had been working for some time, being on his feet for eleven hours without difficulty.

CASE IV.—J. T., 19 years. The patient stated that a year before admission he fell from a tree, landing on both knees. He was laid up for a week with a swollen, painful right knee. Soon after this he noticed a movable lump and since that time there occurred several attacks of pain and swelling with occasional locking. He said he could feel three separate loose bodies. These were evident on radiographic examination and on December 10, 1931, two loose bodies were removed through a small incision.

Ten days later the joint was again opened through a median patella splitting incision and a third loose body was removed. A large, deep, eroded area was found on the medial condyle, and the alar pad was greatly thickened with several fibrous nodules in its margin. The synovia was purple, velvety, and thickened. In addition to removing the third body, a partial synovectomy was done and the margins of the eroded areas were shaved off.

The patient was up on the eighth day, walking on the twelfth, and discharged on the twentieth. Crutches were discarded at the end of four weeks. At the end of 14 weeks he was working as a floorscraper. He reported at the end of 28 weeks with complete return of function, being able to sit on his heels and with no pain or disability. At the end of 20 months, the report is normal; there is painless motion with no disability.

DISCUSSION

DR. JOHN J. MOORHEAD recalled having on two occasions shown before the Society a series of knee joint cases. He had, and quite recently, prepared a résumé of these which now number 244. He was almost completely in accord with what Doctor Darrach had said in respect to the methods of diagnosis, in respect to the multiplicity of lesions within the joint, and particularly as to operative treatment and postoperative management. One of the most striking demonstrations he had made was that even in the presence of marked damage to the crucial ligaments, nevertheless, function had been maintained. In a number of these cases there have been plateau fractures in which the spine of the tibia was unquestionably damaged. At Reconstruction Hospital he had not been able to pick up a case in which he could be sure there had been a crucial ligament injury. He was particularly glad to hear Doctor

Darrach say that he is in favor of, and employs, the large incision. He has apparently abandoned the median incision in which the patella was split. The mediolateral incision follows the inner margin of the patella because most lesions are on the inner side. That is a very satisfactory incision and can be made on the outer margin instead, if desired. He was likewise pleased to learn that by the use of tourniquet the postoperative effusions had been lessened. That had been his experience. He was interested, also, in Doctor Darrach's remarks as to the development of osteochondritis dissecans and particularly in hearing him say that a history of trauma can be, and often is, obtainable in these cases. He thought the speaker's emphasis on the ultra-aseptic technic most important.

DR. DONALD GORDON thought that to the majority of people who have two good knee joints, Doctor Darrach's presentation would be sufficiently interesting, but to one who has only one it is very pleasant to see the success with which knee joints can be exposed and patients quickly turned out of the hospital without the infections that were held up before us in the old days. The surgical profession should emphasize to the medical profession the importance of these so called minor pinched lesions, or whatever they might be. If they could be taught to get these cases under proper surgical care before they develop relaxation of the muscles, it would be a great step forward.

DR. CLAY RAY MURRAY said prompt recognition of many of these injuries to the knee joint is of the utmost importance. It is early attention to many of them which spares the joint from subsequent secondary degenerative changes. One of the chief obstacles to prompt and adequate care is the frequency of the diagnosis of traumatic synovitis with effusion. It may be almost categorically stated that accumulation of fluid in a knee joint to an appreciable amount in twelve hours or less after a trauma to a previously normal knee never represents a traumatic synovitis, but a hemarthrosis. Any diagnosis made under these circumstances must explain bleeding into the joint cavity. If this is understood there is much less likelihood of passing over derangements of the joint, and much less chance of overlooking pathology on exploration of the joint, and much less satisfaction in the use of an incision inadequate for thorough exploration.

The statement in reference to early fluid accumulation after knee joint injury, often after relatively mild indirect trauma, and hemarthrosis, and incidentally the safety of knee joint aspiration under proper technic, is supported by the results of several hundred aspirations over a period of five years without the occurrence of anything remotely resembling infection, and with, so far as I know in early cases, not a single exception to the rule that early accumulation means hemarthrosis.

DOCTOR DARRACH said in regarding the advantage of getting these knees fairly early, I have completely shifted my point of view. I used to let them

wait until six or seven attacks, that is until the condition seriously interfered with their pleasure. I have seen a lot of those fellows since and many have had their knee joints operated on by someone else, or else the joints are creaky and slippery, or they have given up their tennis or are playing only seven holes of golf. We treat our automobiles better. If we get anything knocking in it, we get it out, and it seems to me when there is a meniscus or a bit of bone being ground up it should be gotten out. I firmly believe that many chondritic cartilages are not embolic, but just plain trauma. We all know that cartilage does not heal very well. It may be replaced by fibrous tissue. When you are satisfied that there is something wrong with a knee joint, you had best go in and attend to it. My impression is that we have had well over 500 aspirations of the knee joint and I don't believe we have had more than three yellow taps in the whole lot, which is less than 1 per cent in knee joints following trauma. They are not yellow taps, but blood, and you can't get blood unless something tears and gives way; whether it is synovial lining or bone or some part of the joint, these aspirations are bloody.

It took me a long while to come to the free wide incision—about three years ago. That is a long time to wait before profiting by your mistakes. But there are still a lot of peep-hole men.

To persuade patients to move their knees requires a good deal of team work. The patients are talked to beforehand and almost before they come out of the anesthetic. Everyone who goes by—internes, nurses, and others—tells the patient to move his knee. Some patients will do so at once; others will not make a quiver and require four or five days before beginning to contract their muscles. The sooner those muscles begin working together on their own, however, the sooner will you have a recovery. The only way is to make *them* do it. We do not put them up in plaster.

BRIEF COMMUNICATIONS AND CASE REPORTS

DUODENAL ULCER AND BANTI'S DISEASE*

JOHN E. JENNINGS, M.D.

BROOKLYN, N. Y.

CASE REPORT.—Louis S., aged 30, an Italian barber, had been treated for ulcer of the stomach for ten years and stated that he noticed tarry stools five years before that. Admitted to St. Peter's Hospital, Brooklyn, July 1, 1929, he had been vomiting blood every three to six hours for three days and had noticed several massive tarry stools. He was exsanguinated. Hemoglobin 30 per cent. Under morphine, glucose, hypodermoclysis, bed, rest and peptonized milk feeding his bleeding ceased and after a transfusion of 500 cc., a gastro-enterostomy, posterior, without clamps, was done. His recovery was uneventful and he was discharged.

He improved under liver extract and iron, doing fairly well for a few months. Then in October, 1930, he again suffered several hemorrhages with massive tarry stools, his hemoglobin again falling to 30 per cent. He returned to the hospital where, after several weeks of preparation and another preoperative transfusion, an indurated ulcer of his pyloric and postpyloric region was excised with the mucous membrane of half the antrum and pylorus; shelling this out beneath the muscular coats after the method described by Bancroft, the ulcer was removed, the duodenum and stomach closed with exclusion of the pylorus. The gastro-enterostomy was in good condition and the pathologic report of tissue removed was nonmalignant, chronic ulcer.

For eight months the patient did fairly well. Then, again, he passed several large tarry stools and was sent to the hospital for bed, rest and care. He did well and was discharged in a month, November 15, 1931.

For more than two years he was moderately well, but his hemoglobin, in spite of liver feeding, did not rise above 50 per cent. In March, 1934, he passed tarry stools once more and again entered the hospital. This time it was found that his spleen was markedly enlarged. A diagnosis of Banti's disease was made. On May 2, 1934, operation showed a normal gastro-enterostomy and a large spleen was removed. After a rather stormy convalescence, he was discharged on August 7, 1934. He has regained his strength, gained 30 pounds in weight, and is at work on a full maintenance diet (January 7, 1935). *Pathologic Report*.—Banti's Disease (Fibroadenoma of Spleen).

Comment.—The case is presented of a man who had a duodenal ulcer, with repeated hemorrhages, and splenic anemia. The splenic anemia was undoubtedly present at the beginning but its character was unrecognized. The differentiation between hemorrhage due to splenic anemia and to duodenal ulcer is very interesting.

DIAPHRAGMATIC HERNIA

DR. JOHN E. JENNINGS presented Henry A., admitted February 16, 1921; discharged March 9, 1921. In May, 1918, while in action, patient was gassed and sustained a shrapnel

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wound of the left chest. Empyema followed which was drained. In August, 1919, he vomited a large amount of blood and has had repeated recurrences of hematemesis since. He has lost weight and strength. Moderate occasional pain in the epigastrium. He now vomits everything he eats. On examination—a sick man evidently dehydrated and somewhat emaciated. His chest shows a few subcrepitant râles at the right apex. A rough first sound over the precordia with a presystolic thrill. Two scars, one in the left anterior axillary line at the third interspace and another in the seventh interspace at the posterior axillary line. A movable right kidney was recognized. Otherwise his abdominal examination was negative. Radiographic examination of the gastro-intestinal tract shows a diaphragmatic hernia with pyloric end of the stomach or duodenum in the left thoracic cavity forming an almost complete obstruction. There is shot or shrapnel in the left thoracic wall posterior at the level of the fifth interspace and below. Fluoroscopic examination shows: Plain—what seems to be a gas bubble in the stomach above level of the left diaphragm. Density as of partially collapsed lung above this. With barium meal—definite diaphragmatic hernia through left dome.

Operation.—February 21, 1921.—After a transfusion of 500 cc. an incision from the tip of the ensiform downward and outward to a point just below the tip of the left twelfth rib. Fault in the diaphragm containing practically all of the lesser curvature and a considerable portion of the fundus of the stomach about three inches to the left of the midline just lateral to the pericardium. It also contained the tip of the spleen. The opening was stretched, the adherent stomach freed and pulled down and the opening closed with a double row of sutures of chromic gut. The abdomen was closed without drain. His recovery was uneventful.

Follow up a year later showed him well and symptom free. Sometime in 1925 he began to have symptoms of indigestion—distress after eating, with nausea and occasional vomiting. He was told he had an ulcer and put on a diet. He noticed tarry stools several months ago, has lost flesh and strength, and on October 27, 1927, vomited what he says was a large amount of blood. He was again admitted to the Brooklyn Hospital on December 8, 1927. Hemoglobin 60 per cent. Red blood cells 4,800,000. Radiographic examination showed: The proximal three inches of stomach within the left chest. At the point where the stomach passes through the diaphragm there is a definite band like a narrowing of the lumen so that it measures only about an inch. Meal passes readily into the small intestine.

Second Operation.—On February 21, 1928, an incision was made removing the old scar and separating the adhesions between the stomach, the great omentum and the anterior abdominal wall. The opening in the diaphragm was found just to the left of the spine and well posterior, the aorta behind, the heart in front, the esophagus just to the inner side. It was a recurrence through the median extremity of the sutured hernia of seven years before. The opening would admit two fingers but not three. It was surrounded by a fibrous ring. The stomach was firmly adherent to the pleura and lung. An attempt to free it was begun but stopped because of hemorrhage. The ring was then cut with a probe-pointed bistoury outward toward the chest wall and the opening enlarged to admit the hand, thus freeing the hour-glass constriction of the stomach. The abdomen was closed without drainage. His convalescence was without incident.

In November, 1929, he was readmitted for hemoptysis, his gastric symptoms having been relieved since the operation eighteen months previous. This was believed to be due to an abscess of the left lower lobe of the lung where a radiogram revealed an area of thickening of lung or pleura. The irregular shadow of a shrapnel fragment was thought to lie within this area. He had no evidence of tubercular involvement. Rest in bed with postural drainage relieved his cough and hemoptysis. He did not desire operative treatment and was allowed to go home. He has been well and able to work for six years, and is offered as a case of gastric hemorrhage with diaphragmatic hernia,

treated for some time as an ulcer of the stomach—operated upon with recovery. There was a recurrence of hernia and again an erroneous diagnosis of ulcer. He was operated upon and the obstruction was relieved by section of the diaphragm with recovery. Convalescence was complicated by a foreign body abscess of left lung.

HIRSUTE VIRILISM

DR. JOHN E. JENNINGS presented H. R., female, 27; single; complaining of obesity, hirsutism, amenorrhea. Her father died of cancer. Her mother was psychopathic—melancholia. She has been obese since the age of 15. The obesity has been progressive; her weight is now 180. Until five years ago she had scant hair distribution over her arms, legs, and a little at the lower end of the spine. Within these five years hair has grown much thicker and now covers the trunk, front and back, parts of face, and all the extremities. Her periods began at 18 and have occurred about once a year, lasting three days with scant flow.

A short, heavy young woman with a round moon face. She has hair on her chin, both cheeks and upper lip. There are many fine punctate scars from the electrolysis over the lower half of her face. Obesity most marked in upper half of body including her face, back pads and girdle fat. Thick hair over sternum. Male distribution over abdomen, back and extremities. There is marked hypertrophy of the clitoris which is four times its normal size. The nymphae are barely present. On rectal examination a small uterus can be made out. There are no pelvic masses palpable. Otherwise physical examination is negative. Blood and urine examination normal. Basal metabolic rate minus 12. Her eye grounds and visual fields are normal. Roentgen ray examination of skull shows a small sella turcica. The clinoid processes are in close approximation with the ends, almost in apposition. There is no evidence of necrosis or erosion. It was decided to explore the adrenals for the presence of a cortical neoplasm, or, failing this, for diffuse hyperplasia.

Operation.—On November 2, 1934, under spinal anesthesia, an incision was made over the course of the eleventh right rib which, with the twelfth right, was widely retracted. The kidney exposed and drawn down with the suprarenal capsule. This appeared large and diffusely thickened but with no localized induration or tumefaction. It was considered a diffuse hyperplasia and the wound closed. The immediate postoperative course was stormy. The first day her temperature rose to 105.8°, respiration 40, pulse 156. The second day T 103.8°, P 136, R 36, gradually reaching normal in four days. She had received interrennin b.i.d. before operation and this was continued for three days after operation, with 1,000 cc. 5 per cent glucose in clyses t.i.d. The wound healed *per primam*.

On December 4, 1934, under spinal anesthesia, an incision, slightly lower than the previous operation on the right, was made following the course of the twelfth rib on the left, from the angle to two inches in front of its tip. The muscles were cut and the twelfth rib removed subperiosteally from its tip to the angle. The kidney was freed from its fatty capsule and drawn down with the suprarenal. The anterior face of the suprarenal was dissected free and the kidney separated from its posterior surface. Ligatures cast about the superior and inferior poles, cut and ligature thrown about the median blood supply and the gland removed. It was large and firm with no localized tumefaction. The postoperative reaction was very mild in comparison with that following the previous operation. She received interrennin, glucose and sedatives as before. She was discharged December 20, 1934.

Pathologic Examination.—A report, of the tissue removed, by Doctor Goldzieher, to whom I am indebted for the privilege of seeing this case, showed the cortex of the adrenal definitely enlarged. Several distinct layers can be recognized. Outwards, the glomerular and trabecular zones stand out by their increased lipid load. The inner-

most part of the trabecular layer and the reticular zone are chiefly responsible for the enlargement of the cortex. They do not contain any visible lipoids. The cytoplasm of their cells stains intensely with eosin. This hyperplastic zone stands out by its intensive stain so much that it becomes visible to the naked eye. There is also a substantial ingrowth of the cortical tissue towards the center occupying the territory of the medulla. The latter consists mainly of scattered islands of chromaffin imbedded in the hyperplastic cortical growth. The latter consists mostly of darkly stained cells and only occasional islands of lipoid bearing elements. The chromaffin cells are densely packed and form syncytial complexes with several nuclei. The large veins within the central portion of the gland show fairly bulky musculature which, in some veins, is definitely hyperplastic. *Diagnosis.*—Cortical hyperplasia restricted to the inner layers, typical of the hyperfunctioning cortex; substitution of the medulla by cortical tissue and hyperplasia of the remaining medullary tissue; incipient hypertrophy of the venous musculature.

It is as yet too soon to form any opinion as to the effect if any, of this operation. The patient still retains her fat, her hair and her amenorrhea.

DR. M. A. GOLDZIEHER (by invitation) said that surgical conditions of the adrenals have been recognized clinically only in recent times. Previously they belonged to the pathologist only, but recent advances in endocrinology have enabled us to diagnose some of these conditions in vivo. Tumors of the adrenal glands, particularly of the cortex, have been operated on before and are known to have produced symptomatology of tumor nature as well as of the endocrine type. It was not known until quite recently, however, that simple hyperplastic enlargement of the adrenal cortex is also capable of causing symptoms directly due to hormonal effects that could be remedied by surgical methods. The case presented by Doctor Jennings attempts to illustrate that particular type of case.

What are the grounds on which we stand when we claim that the mere, and sometimes only moderate, enlargement of the adrenal cortex is capable of producing symptoms such as were present in this and other cases? What is the basis by which we can differentiate whether we are dealing with primary adrenal disease or merely with a secondary symptom complex due to hyperactivity of some other endocrine gland such as the pituitary? Among the hormone effects of the adrenal cortex, so far, only three are definitely known: (1) The life preserving effect of the adrenal cortical hormone, (2) The effect, as shown experimentally and clinically, that induces a deposit of fatty substances in the body thereby increasing weight, and (3) the action of the adrenal cortex upon the gonads, which varies according to the age and sex of the individual.

We have every reason to believe, both on the basis of clinical observation and animal experimentation, that an excess of cortical hormone or of one of the cortical hormones, if you prefer, is capable of producing obesity of a peculiar type, which, in our personal clinical experience, is characterized by a remarkable predilection for certain parts of the body. It leaves the lower extremities and forearms free and presents itself mainly as a diffuse trunk obesity with heavy neck and a full moon face.

It seems to be generally recognized that pathologic enlargement of the

adrenal cortex during embryonal life is intimately related to the development of pseudohermaphroditism. Enlargement of the adrenal cortex either of neoplastic or of diffuse hyperplastic type has been observed in children, particularly in the female child with the clinical picture of precocious puberty. In adult females it has been found in a fairly large number of cases characterized by obesity and menstrual disorders, while the syndrome apparently does not occur in the male. Another sign that always occurs in these cases is the appearance of hair of the masculine type over the body and particularly in the face. Male hair distribution or the phenomenon of hair in the face is not unusual, of course, in the endocrinopathies and could not be considered as a pathognomonic sign; however, the adrenal type of hirsutism is rather characteristic. I can look back upon many years of experience in this field from the time when we observed adrenal changes only postmortem and diagnosed adrenal cortical enlargement or adenoma before we opened up the body by a peculiar type of hirsutism, namely, the coarse black hair limited to the chin and the inframandibular region. The side of the face and the upper lip do not evenly share in the facial hairiness in contrast to the hirsutism in the pituitary type, in which type the hair is distributed primarily on the cheeks and upper lip and is soft in the beginning, before cosmetic procedures are resorted to.

The case Doctor Jennings has presented showed a full moon face and obesity of the adrenal type; the hairiness of the face and body was similar to that noticed postmortem in so many cases of adrenal hyperplasia; and, finally, on endocrine examination, the patient did not show any of the signs which we consider characteristic of pituitary disease. The left adrenal gland presented, after removal, a very remarkable kind of anatomic lesion, that I have seen only in these clinical types, namely, an enlargement of the intermediary zone and a content mainly of reticularis and the inner part of the fascicularis. This zone is not only tremendously enlarged, but it is stained differently from the rest of the adrenal cortex: it stands out as a dark reddish band, a lesion not known in any other human condition but very well known in animal experimentation. It has been described by investigators in England as zone X of the adrenal cortex and is considered to be a sign of sexual immaturity in the female animal.

PARTIAL GASTRECTOMY FOR BLEEDING DUODENAL ULCER*

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CASE REPORT.—A male, 56 years old, who was admitted to Mount Sinai Hospital on September 27, 1934, with the following history: Six years ago he began to suffer from epigastric pain which came on after meals and was relieved by food. He was put on a fairly strict diet and his symptoms became less severe until a few weeks before his admission. At that time although radiographic examinations were negative, a diagnosis of duodenal ulcer was made. Rehfuess test meal showed free acid 75, total acidity 115.

* Presented before the New York Surgical Society, January 9, 1935.

One day previous to his admission to Mount Sinai Hospital he suddenly vomited a large amount of bright red blood and he noticed blood in his stools. His blood pressure on admission was 90/50 and his hemoglobin was 50 per cent with 3,000,000 red blood cells. During the first few days after his admission his symptoms were not alarming. He was given glucose solution intravenously and during the next two weeks received a number of subcutaneous infusions. It was hoped that the patient would gradually recover from his hemorrhage and be strong enough for another radiographic examination. On October 22, about three and a half weeks after his admission, he went into a mild collapse from which he rallied rather rapidly. In view of the fact that surgical interference was not contemplated at that time he was transferred to the Medical Service for further observation and treatment. Two days after his transfer, the symptoms became worse. His hemoglobin suddenly dropped to 20 per cent and his blood pressure was 112/70. However, in spite of repeated citrate transfusions his blood pressure continued to fall to 70/36 and his hemoglobin to 25 per cent. The patient was evidently losing the blood as fast as it was put in by transfusion. Despite careful diet and milk drip there seemed to be no tendency for the ulcer to heal. Since his transfer to the Medical Service he had bled constantly and had at least three episodes of massive hemorrhage. In spite of the transfusion of 2,300 cc. of blood (given in four transfusions) his hemoglobin was 24 per cent. It was felt that conservative attempts to cure this ulcer had been exhausted and that in spite of his low hemoglobin surgical interference was indicated in an attempt to save this man's life. For this reason he was transferred back to the Surgical Service and an emergency partial gastrectomy for bleeding duodenal ulcer was performed on October 30.

Under general anesthesia a midline incision was made between the ensiform process and the umbilicus. A duodenal ulcer was found at the superior and posterior wall of the duodenum just below the pylorus. The stomach was divided just above the reentrant angle in typical fashion after the gastrocolic ligament had been ligated. The stomach was then pulled over toward the right and the pancreas with the duodenal ulcer attached to it was exposed. The duodenum was then freed from its adhesions posteriorly. During this process the duodenal wall tore. The ulcer base was formed by the head of the pancreas. It showed a marked infiltration and was about the size of a fingernail. After the duodenum had been freed sufficiently, three tiers of layer suture were applied to the duodenum. The lumen of the duodenum as it presented itself was comparatively small, hardly admitting the little finger. Catgut was used for the first and second layers and Pagenstecher for the third layer, thus extraperitonealizing the duodenal stump. The patient's pulse by this time was 150 and it was deemed advisable to perform a Weir button gastro-enterostomy in order to expedite the operation. A small tube was placed to the duodenal stump. During the operation an intravenous saline infusion was given.

The patient received a transfusion immediately after his return to the ward. His blood pressure on the day following the operation had risen to 135/60 and his hemoglobin had gone up to 39 per cent. The patient made an uneventful recovery and was discharged from the hospital on December 11, 1934. Hemoglobin 54 per cent. The button was passed November 12.

Roentgen ray examination December 28, 1934, showed a normally functioning stoma with rapid emptying time. A postoperative Rehfuess showed free acidity 18, total acidity 30. Hemoglobin 65 per cent.

Doctor Lewisohn stated that contrary to the general opinion the mortality from bleeding ulcers is high. Undoubtedly a large number of gastric hemorrhages stop spontaneously. However, when conservatism fails, radical surgery (partial gastrectomy) presents the only reasonable method of approach. Gastro-enterostomy is an absolutely futile operation in bleeding gastroduodenal ulcers. This patient was shown in order to demonstrate that the major operation of gastric resection may be performed successfully in a patient with a hemoglobin of 24 per cent.

VALVULAR PNEUMOPERITONEUM

COMPLICATING MUCOCELLULAR CARCINOMA OF THE STOMACH

GORDON B. MEYERS, M.D., THOMAS H. BATE, M.D.,
AND JAMES E. LOFSTROM, M.D.

DETROIT, MICH.

FROM THE DETROIT RECEIVING HOSPITAL AND THE COLLEGE OF MEDICINE OF WAYNE UNIVERSITY

THE usual result of the rupture of a hollow abdominal viscus is a general peritonitis. Very occasionally a spontaneous valve-like closure occurs, which prevents the free extravasation of fluid into the peritoneal cavity but permits the escape of air. The resulting clinical picture is that of an increasing abdominal distention without peritonitis or ileus. Fluoroscopic examination in such cases shows large quantities of free air beneath the diaphragm and thus reveals the cause of the distension.

In 1932 Singer¹ collected 24 cases of this type, all from foreign literature, and reported four of his own under the title of "Valvular Pneumoperitoneum." In two of the latter the diagnosis was made prior to fluoroscopy by the characteristic clinical findings.

A case was recently observed of gastric carcinoma with spontaneous perforation leading to pneumoperitoneum without appreciable peritonitis. The valve-like mechanism which permitted air but not fluid to escape from the stomach was demonstrated at autopsy.

CASE REPORT

A female, aged 45, was admitted to the Receiving Hospital, Detroit, October 9, 1934. *Chief Complaint.*—Dysphagia; abdominal distention; weight loss.

Present Illness.—In January, 1934, the patient began to have difficulty in swallowing solid food, which seemed to lodge at a point opposite the xiphoid process, causing a choking sensation, but provoking no pain. As a consequence she restricted her diet, in the main, to liquids. At times even these seemed to be blocked on their way to the stomach. She had noticed fullness after eating for some months, which she attributed to gas, despite the rarity of belching. There was no appreciable distention until the week prior to entry when the abdomen progressively increased in size. There was some discomfort attributable to the distention, but never any severe abdominal pain. The appetite was fairly good. There was no history of nausea or vomiting. The bowel movements were fairly regular throughout the illness. The patient lost a total of 70 pounds in weight and became progressively weaker. There were no cardio-respiratory nor urinary symptoms.

Physical Examination.—There was marked tenderness upon pressure over the left tenth rib in the midaxillary line, but no crepitus nor deformity. The percussion note was tympanitic over the entire liver area. There were diminished breath and voice sounds with tactile fremitus at both bases posteriorly, but no râles nor changes in percussion note. The heart was negative. Blood pressure 110/70. The abdomen was symmetrically distended and barrel shaped. The panniculus was very thin. There was slight bulging with flatness in the flanks, shifting with change in position, but no fluid wave was obtained. The remainder of the abdomen was tympanitic. There was no tenderness nor rigidity. The spleen and liver were not felt. There was a firm, slightly tender, irregular mass in the midline, arising from the pelvis and extending four finger breadths above the symphysis. On vaginal examination this appeared to be a sphere about 12 to 14 cm. in diameter. Although in the midline, the mass was freely movable to the left for

a distance of four cm. A nodule three cm. in diameter was felt in the right adnexal region. Both masses seemed to be distinct from the uterus which was small and was displaced posteriorly.

Laboratory Reports—Urine, negative. Sahli Hb 88 grams; R.B.C. 3,600,000; W.B.C. 6,000; N.F.N. 9 per cent; F.N. 62 per cent; Eosinophiles 1 per cent; Lymphocytes 28 per cent. Kline negative. Stools showed a consistent trace of occult blood. Six sputa were negative for tubercle bacilli.

Roentgenogram of the chest showed peribronchial infiltration at the left base and in the middle and lower right lobes with a small amount of fluid in the interlobar fissure. There was an old healed tuberculous focus in the second interspace on the right. Beneath the diaphragm there was a large amount of air, causing an upward displacement (Fig. 1). The diaphragm moved fairly freely. Complete gastro-intestinal series showed no barium



FIG 1—Radiogram of chest showing large amount of air beneath the diaphragm and peribronchial infiltration due to pulmonary metastases.

escaping from any part of the tract. The only positive findings were a slight delay in emptying of the esophagus and a slight irregularity at the cardiac end of the stomach. These findings were mistakenly attributed to positive pressure from the pneumoperitoneum.

Course in Hospital.—The temperature was, for the most part, normal but rose to between 99 and 100 on four occasions. The pulse ranged between 70 and 120, averaging 90. On October 15, 150 cc. of slightly cloudy yellowish-green fluid were removed from the abdomen. The ascitic fluid showed a specific gravity of 1.015, a three plus albumin and contained 1,440 W.B.C. per cubic Mm., 95 per cent of which were polymorphonuclears. No organisms were found in the smear of the sediment and there was no growth after three days' culture. A specimen of gas was obtained from the peritoneum, which on analysis showed 7 per cent carbon dioxide, 2 per cent oxygen and 91 per cent nitrogen.

Operation.—October 27, 1934, under spinal anesthesia. Upon opening the abdomen a large amount of odorless gas escaped and the distention disappeared. There was about 500 cc. of a serosanguinous fluid in the peritoneal cavity, but no definite inflammatory reaction in the peritoneum. Bilateral solid tumors of the ovaries were found and removed. The upper abdomen was explored by palpation and by means of a Cameron light, but no further pathology was noted. The patient did not react well to the operation and expired a few hours later.

Pathologic Diagnosis.—The gross and microscopic appearance of both ovaries was characteristic of mucocellular carcinoma (Krukenberg tumor).

Autopsy.—*Thoracic Cavity.*—Scattered diffusely throughout both lung fields were fine white nodules measuring from one to three Mm. in diameter. On microscopic examination these proved to be areas of metastatic new growth.

Abdominal Cavity.—Upon opening the abdomen a considerable quantity of odorless gas rushed out. There was about 300 cc. of nonpurulent sanguinous fluid in the abdominal cavity. There was no evidence of peritoneal reaction. The omentum was firmly attached to the cardia of the stomach. Separation of the adhesions revealed a dense white mass of new growth tissue which encircled the cardiac orifice and extended horizontally across the anterior aspect of the stomach in a finger-like projection. At the tip of this process and uncovered by omentum, there was a perforation five Mm. in diameter.

Microscopic examination of the stomach wall showed the typical signet ring, mucin containing cells characteristic of mucocellular carcinoma.

Comment.—When the excised stomach was forcibly distended with water, no fluid passed through the perforation. However, when the stomach was artificially inflated, air escaped readily.

The valve-like mechanism which prevented the extravasation of fluid but permitted the escape of air through the perforation during life and at the autopsy was revealed when the stomach was opened. Projecting into the lumen of the stomach from a point five Mm. below the perforation (Fig. 2) there was a fold of mucosa two cm. in length and five Mm. in thickness. The fold was movable at its base in the manner of a hinge. Fluid filling the stomach from its most dependent portion (as occurs physiologically) forced the mucosal flap upward against the stomach wall so as to cover the perforation. A sufficiently tight closure was thus obtained so that no water escaped when the fluid level rose higher.

Air, on the other hand, collected in the fundus and filled the stomach from above downwards. The mucosal fold was thus forced downwards away from the perforation, leaving no obstacle to the escape of air. The position of the perforation high up on the anterior wall of the stomach was probably an additional factor which favored the escape of air and hindered the egress of fluid.



FIG. 2. — Cross-section of stomach wall, showing perforation and valve action of mucosal fold. Solid black indicates carcinomatous infiltration. Shaded section indicates normal stomach.

SUMMARY

A case of mucocellular carcinoma of the stomach is reported, in which

spontaneous perforation occurred leading to pneumoperitoneum without peritonitis. The valve-like mechanism which permitted the escape of air but prevented the free extravasation of fluid into the peritoneal cavity was demonstrated at autopsy.

REFERENCE

- ¹ Singer, H. A. Valvular Pneumoperitoneum. J.A.M.A., vol. 99, p. 2177, 1932.

STAB WOUND OF THE HEART

REPORT OF A CASE

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THE following case is reported not only because of the relative infrequency of this type of injury but also because of several unusual associated conditions.

CASE REPORT.—Horace D., a 15-year-old colored boy, was admitted to the Saint Philip Hospital July 26, 1934. During an altercation he was stabbed in the left chest with a large pocket knife. On admission the patient was unconscious and profoundly shocked. The skin was moist and cool, the pulse imperceptible and the blood pressure could not be obtained. Respiration was labored and sternomastoid in type. Blood escaped freely from a sucking wound four cm. in length situated about three cm. to the left of the sternum and immediately over the fourth and fifth costal cartilages which had been completely divided (Fig. 1). The entire left chest was flat to percussion, breath sounds could not be heard and the area of cardiac dullness was markedly shifted to the right. The veins of the neck were not dilated. The heart sounds, though feeble, could be distinctly heard; the rate was about 150 to the minute. A snug dressing checked the external bleeding, the foot of the bed was elevated, 45 mg. of ephedrin were injected subcutaneously and an intravenous injection of normal saline started. The condition of the patient improved immediately; the radial pulse could be palpated and the systolic blood pressure rose to 60 Mm. Hg. The external bleeding increasing, the edges of the wound were separated and as the left pleural cavity was filled with blood a gauze pack was inserted between the severed cartilages of the fourth and fifth ribs to check internal bleeding from the margins of the wound. While this was being done the boy regained consciousness, became combative and had to be restrained. The location of the wound, the massive hemothorax, and the clearness of the heart sounds suggested an intrapleural hemorrhage from a severed internal mammary artery instead of an injury to the heart, which was suspected when the patient was first seen.

Operation.—The intravenous infusion was continued as the patient was moved to the operating room, and the blood pressure gradually rose from 70/40 to 90/48. The operation was begun under local anesthesia 50 minutes after the injury. The incision resulting from the stab wound was extended upward parallel to the sternum and downward and outward in the direction of the left costal margin. The gauze pack was removed, and the pleural cavity was opened under nitrous oxide-oxygen anesthesia. The third and fifth intercostal spaces were incised laterally and the severed fourth and fifth costal cartilages were reflected outward upon the costochondral junctions as a hinge. This permitted an inspection of the left pleural cavity through an opening

about five cm. square. A large amount of blood was aspirated from the pleural cavity and it was then found that the bleeding came from a rent in the pericardium about two cm. in length. The pericardial sac was opened widely and the heart was drawn up into

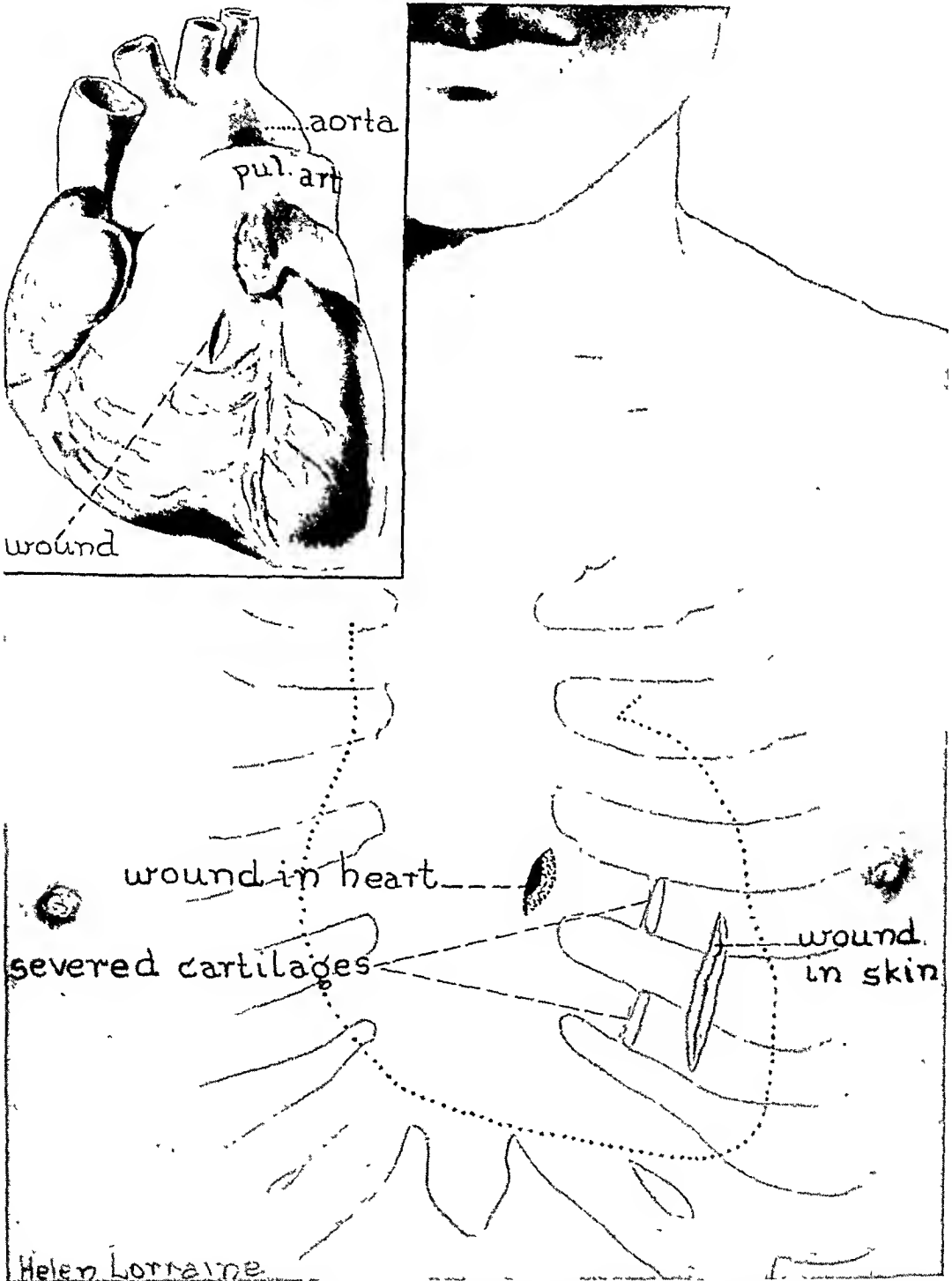


FIG. 1.—The obliquity of the wound in the skin, costal cartilages and heart is indicated in the larger drawing. The insert shows the relative size and position of the wound in the right ventricle.

view exposing a wound of the right ventricle about one and a half cm. in length. This was situated one cm. from the left coronary artery and about two cm. from the base of the pulmonary artery. The heart appeared small and anemic. A traction suture was

STAB WOUND OF HEART

placed in the apex of the heart and a finger inserted in the wound checked the bleeding until the defect could be sutured. Because of the location of the thoracotomy in the left chest, and the shift of the mediastinum to the right, considerable tension was placed on the base of the heart whenever this organ was brought up into the wound. This resulted in such feeble and irregular heart action that it was necessary to replace the heart in the pericardial sac between each suture so that it could regain its regular though rapid rhythm. Four chromic catgut sutures closed the defect. The posterior surface of the heart was exposed but there was no wound of exit. The condition of the patient at this time was distinctly unfavorable. The blood pressure rapidly fell to 65/50 and the pulse could not be palpated. The head of the table was lowered and the intravenous fluids increased. The rent in the pericardium was closed except for a small opening at the lower angle for drainage. The costal cartilages were replaced and the



FIG. 2.—Roentgenogram of the chest one week after operation showing considerable displacement of the heart to the right and fluid in the left pleural cavity.



FIG. 3.—Roentgenogram of the chest six weeks after operation showing almost complete return to normal of heart and lungs.

chest wall was closed while the anesthetist applied positive pressure to expand the lung. Immediately after the conclusion of the operation the face and neck of the patient suddenly became edematous. The swelling of the eyelids was so excessive that the sclera could not be demonstrated. The head was raised, a transfusion of 550 cc. of blood was given with an immediate improvement in the condition of the patient, the edema rapidly subsiding.

An electrocardiogram made one hour after the operation was negative except for a sinus tachycardia of 150 (Fig. 4).

Postoperative Course.—July 27, 1934. On the day after operation the temperature was 103°; pulse 120; and respiration 40. The blood pressure was 100/50. The patient was delirious. The entire abdomen was tender and rigid. Liver dulness was present at the costal margin. There was no evidence of free fluid in the abdominal cavity. A transfusion of 400 cc. of whole blood was given. The heart was markedly displaced to

the right. The following day the temperature was 104° ; pulse 130; and respiration 40. A loud to-and-fro friction rub synchronous with the heart was heard over the precordium. A large amount of air and 300 cc. of bloody fluid were withdrawn from the left pleural cavity. The tenderness and muscle spasm of the abdomen continued.

On July 29 following a third transfusion of 400 cc. of whole blood the temperature rose to 105.2° ; pulse 140; and respiration 34. The patient continued irrational. An electrocardiogram showed evidence of definite myocardial damage similar to that seen in coronary occlusion (Fig. 4). Tenderness of the abdomen persisted. The following

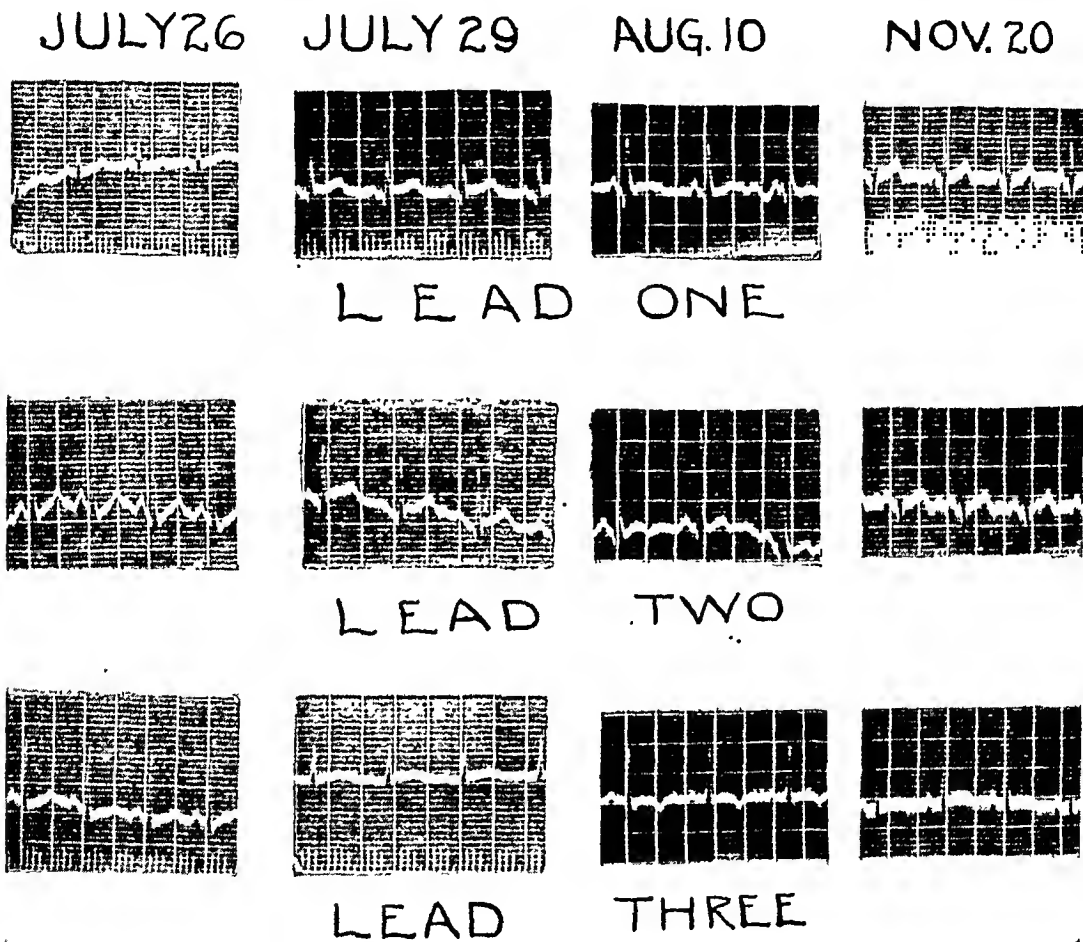


FIG. 4.—July 26.—One hour after operation. Sinus tachycardia, rate 150. Remarks: There is no definite evidence of myocardial damage. July 29.—Three days after operation. Sinus tachycardia, rate 136. Lead 1. Slightly high take off S-T interval. Lead 2. Slightly high take off S-T interval. Lead 3. Low T-wave. Remarks: The S-T phase is definitely above the base line in Leads 1 and 2; the T-waves are upright in all leads. August 10.—Fifteen days after operation. Regular sinus rhythm, rate 100. Lead 1. Slight slurring of Q.R.S., with low T-wave. Lead 2. Slight slurring of Q.R.S. Inverted T-wave. Lead 3. Slight humping of S-T interval. Inverted T-wave. Remarks: The increased upward curve in the S-T phase and the inversion of the T-waves in Leads 2 and 3 is suggestive of the electrocardiographic findings in coronary occlusion. November 20.—One hundred and seventeen days after operation. Sinus tachycardia, rate 136. Remarks: The rapid pulse rate was due to excitement. All electrocardiographic evidence of myocardial damage has disappeared. (Electrocardiograms read by Drs. P. D. Camp and Kinloch Nelson.)

day the temperature fell to 101° ; pulse 100; and respiration 30. The general condition was much improved; the patient was rational for the first time since admission. He had no recollection of happenings on the day of the injury. The abdominal rigidity persisted but the tenderness was less marked.

On August 2, the temperature was 100° ; pulse 110; and the respirations rapid and labored. Five hundred and fifty cc. of bloody fluid were withdrawn from the left pleural cavity with immediate improvement. A roentgen ray showed considerable displacement

of the heart to the right and the left pleural cavity contained a small amount of fluid (Fig 2). By August 9 the temperature had fallen to 98°; pulse 90; and respiration 22. The friction rub had disappeared; the heart sounds were distinctly heard and of good quality although an electrocardiogram continued to show evidence of myocardial damage (Fig. 4). There was less displacement of the heart to the right. Examination of the abdomen was entirely negative.

An uncomplicated convalescence followed and on September 11 the patient was discharged from the hospital in good condition 47 days after operation. His hospital stay had been prolonged for three weeks as a safeguard against too early activity following his return home. A roentgen ray examination showed some lack of aeration in the left lung with a slight cardiac displacement (Fig. 3). The patient showed no ill effects from his recent injury. Heart sounds were of good quality and examination of the lungs was negative to percussion and auscultation. Electrocardiogram negative. The incision was entirely healed (Fig. 5.)

Comment.—This patient did not present the classical signs and symptoms of a wound of the heart. Due to the large opening in the pericardium, which permitted the blood to escape freely into the pleural cavity, tamponage did not occur, and shock and hemorrhage into the left chest were the outstanding preoperative findings. Had the true nature of the injury been recognized before operation a more medial approach would have facilitated the operation.

The sudden edema of the face and neck at the end of the operation was probably due to several factors. The patient was operated upon in the Trendelenberg position and it was thought that the large amount of normal saline injected intravenously diluted the diminished serum protein of the blood to such a degree that the fluid escaped into the tissues in the most dependent portion of the body. The edema disappeared rapidly following elevation of the head and a blood transfusion.

The unexplained and disquieting abdominal symptoms which persisted for ten days following the injury probably were referred from the pericardium as there was no evidence of intra-abdominal injury and the friction rub and abdominal tenderness disappeared simultaneously.

A case of stab wound of the right ventricle with operation and recovery has been presented. This is the fifth heart wound successfully treated at



FIG. 5.—Photograph of patient, 46 days after operation. The wound is completely healed and the heart and lungs are normal to physical examination.

the Medical College of Virginia Hospitals during the past four years. The first four cases were operated upon and reported by Dr. I. A. Bigger,¹ to whom I am indebted for the privilege of operating upon this patient.

REFERENCE

- ¹ Bigger, I. A., and Porter, William B.: Wounds of the Heart. *Inter. Clin.*, vol. I, Ser. 44, pp. 133-159, 1934.

HERNIA INTO UMBILICAL CORD

METHOD OF RECONSTRUCTION OF THE UMBILICUS

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IN EARLY embryonal life, before closure of the abdominal wall, the intestines are located in the umbilical coelom, outside of the abdominal cavity; at the beginning of the third month of intra-uterine life the viscera gradually recede into the abdominal cavity due to the mutual approach and ultimate merging of the visceral plates from both sides. Simultaneously, the broad communication between the intestines and the vitelline membranes is reduced and finally obliterated. Occasionally this process is defective and the closure of the abdominal wall fails to be completed; a portion of the abdominal contents remaining outside of the peritoneal cavity, within the umbilical cord, which is improperly called congenital umbilical hernia or hernia of the umbilical cord. Malgaigne suggested that this term is inappropriate for we are not dealing with viscera escaped from the abdominal cavity but with viscera which have never entered it. The term "hernia" is also grossly inaccurate in this respect, that the protrusion is not covered by the peritoneal sac in the strict sense of the word. "Eventration into umbilical cord" would be a more correct description of such formation but the term "congenital umbilical hernia" or "hernia of the umbilical cord" has been sanctioned by common use.

Arbitrarily such herniae may be divided into three groups: (1) The gap at the umbilicus is small and does not cause a marked distention of the umbilical cord. (2) The gap is moderate in size and allows formation of a visible sac. (3) The closure of the abdominal wall is grossly incomplete, leaving a fissure. In the first group a conservative treatment consisting of a prolonged application of pads will usually effect a cure. The third group requires extensive plastic surgery which cannot always be accomplished in one stage. The literature on the treatment of the second group is very scanty, the remarks usually being confined to the statement that after reduction of the hernial contents the opening is closed. An observation of a case belonging

to the second group in a newborn girl confronted the author with the problem of obtaining not only good anatomic but also cosmetic result.

CASE REPORT

CASE REPORT.—A newborn girl was the second child; after its normal delivery in St. Elizabeth Hospital, January 22, 1934, a globular dilatation of the cord was noticed at its fetal end. A cutaneous umbilicus, also called cutis navel or skin navel, was present, *i.e.*, the skin was covering the attachment of the cord, rising to form a cuff one cm. high. The globular formation occupied a portion of the cord starting 2.5 cm. and ending 8.5 cm. from the umbilicus; in other words, it had a diameter of 6 cm.; its covering consisted of a translucent and in places transparent membrane, through which loops of intestines could easily be distinguished. The rest of the cord as well as the placenta revealed no pathology. As there were no signs of obstruction and the infant was apparently exhausted by the rather long delivery, it was deemed advisable to ligate the cord distal to the hernia, apply an alcohol dressing and postpone the operation till the next morning. Sixteen hours after delivery of the infant, the hernia was repaired under local anesthesia.

The membrane, composed largely of amnion and disseminated masses of Wharton's jelly, was incised in an area free of intestines; the sac contained a large portion of small intestines, cecum, appendix, ascending and a part of the transverse colon; no adhesions were present except one area which evidently corresponded to the attachment of the vitello-intestinal duct; after division of this adhesion between small

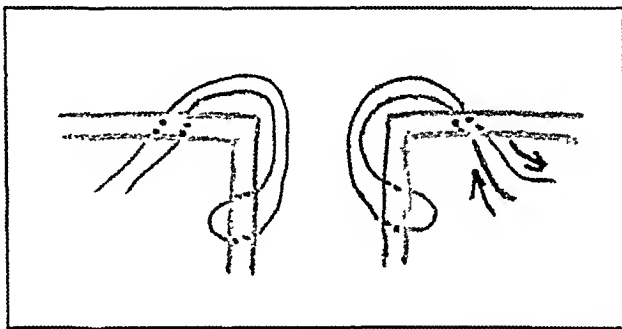


FIG. 1.—Showing method of introducing sutures to effect reconstruction of umbilical dimple.

intestines and the sac, reduction of the contents was accomplished without difficulty. The peritoneum was closed with few interrupted catgut stitches, a purse string stitch offering technical difficulties. The cord, including the sac, was severed transversely leaving a skin covered stump $\frac{1}{2}$ cm. high. A simple closure of the abdominal wall would leave a disfiguring scar; therefore an attempt was made to reconstruct a normal umbilicus by placing silk sutures through the skin in such a manner that they would invert the skin edges (Fig. 1). As such inversion of the skin could produce a *locus minoris resistentiae*, favoring development of an umbilical hernia if the edges should separate, superficial scarification of the cutis forming the cuff was employed to produce firm adherences. After four such inverting sutures had been placed through the skin around the opening in a circular manner, they were tied after preliminary approximation of the muscles and fascia with interrupted stitches of chromic catgut. The skin sutures were removed eight days after the operation, leaving an umbilicus of normal appearance.

A check-up six months and one year after the operation showed a normal appearance of the umbilical dimple and absence of bulging during crying or coughing spells. In other words, a good anatomic and cosmetic result was obtained.

DIFFUSE LIPOMA OF THE RIGHT UPPER EXTREMITY

PROLAN A AND B YIELDED BY BIO-ASSAY OF FAT

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BALTIMORE, MD.

FROM THE LABORATORY OF SURGICAL PATHOLOGY OF THE JOHNS HOPKINS HOSPITAL

APPROXIMATELY 500 fatty tumors have been studied in the Laboratory of Surgical Pathology of the Johns Hopkins Hospital. Table I indicates the character and distribution of these growths. Seven of these growths have presented malignant characteristics, shown histologically by definite proliferative changes, the fat being combined with xanthomatous or myxomatous tissue, and clinically by recurrences or metastases. In 22 cases the

TABLE I

Distribution of 390 Cases of Subcutaneous Lipomas

Shoulder.....	60	Groin.....	10
Back.....	59	Perineum.....	7
Neck.....	54	Hand.....	6
Thigh.....	53	Forearm.....	2
Axilla.....	33	Knee.....	2
Buttocks.....	31	Foot.....	1
Arm.....	23	Scalp.....	1
Leg.....	21	Forehead.....	1
Chest.....	13	Chin.....	1
Abdominal wall.....	12		

Distribution of 70 Cases of Lipoma of the Breast and Viscera

Breast.....	36	Oral cavity.....	3
Small and large intestine	13	Bone.....	2
Joints.....	7	Kidney.....	1
Mesentery and retroperitoneal.....	7	Pleura and mediastinum.....	1

tumors were either multiple or diffuse. In three of the preceding group a definite familial or hereditary tendency could be determined. The following case is reported because of the unusual character of the growth.

CASE REPORT

The patient is a colored girl aged eleven years. The lesion was noted in her right hand during infancy. The attention of the parents was attracted when the child was two years of age. The right hand became puffy. This was supposed to have been caused by a mosquito bite, but it continued to increase. During the next two years the forearm and arm became affected and the swelling extended to the shoulder. When the child was four years old the arm was irradiated. When she was seven a biopsy was made, and irradiation again attempted.

The child entered the Surgical Clinic of the Johns Hopkins Hospital because of the disability caused by the weight of the upper extremity. Examination of the child revealed a well-developed colored girl of eleven years with an enormous upper extremity.

DIFFUSE LIPOMA OF UPPER EXTREMITY

Fig. 1A-B-C (Path. No. 58529).—Photographs of the patient before operation and the region of the right breast and scapula. (A) shows the state of development of the fatty masses are distributed diffusely over the upper extremity probably not precocious for eleven years in this race.



The fatty masses are distributed diffusely over the upper extremity probably not precocious for eleven years in this race. The breast and sex development is

Subcutaneous masses, more or less elastic on palpation, could be felt at the wrist, and these extended above to the trunk, where they became continuous with a large, lobulated mass in front, which occupied the site of the breast, and another large, lobulated mass situated on the posterior surface of the thorax. The right wrist measured 24 cm. in circumference; the midforearm 47 cm. and the midarm 42 cm. The right hand, with the exception of the middle finger, appeared normal. A keloid resulting from a previous operation was found in the deltoid region on the right side. The function of the arm is surprisingly good, when its size is considered. The skin in certain areas seemed corrugated and warty, a change not infrequently associated with lymphedema. The amount of deformity causing a definite scoliosis is best indicated by the accompanying photographs. Definite bony outgrowths could be palpated on the middle finger, on the ulna and humerus.

A roentgen ray examination revealed beneath the shadows caused by the soft parts a widened shaft of the ulna, from which projected several exostoses. These outgrowths were of the rounded osteoma type, and were located at the points of the insertion of tendons (Fig. 2). They apparently developed in response to pressure exerted upon the periosteal muscular attachments by the increasing weight of the tumor. The humerus was similarly affected in the lower third, and here the subperiosteal bone formation can be noted. There are no exostoses in this part of the bone.

September 10, 1934, the right arm was disarticulated at the shoulder joint. The incision in disarticulating at the shoulder joint was carried through part of the tumor which connected the masses on the anterior and posterior surfaces of the thorax. The upper extremity was then sectioned longitudinally. Large, diffuse, subcutaneous collections of fat were found, which in many places extended up to the epidermis. Several large, discrete, fatty tumor masses, some measuring 10 cm. in diameter, were found in the upper forearm and the lower part of the arm. Several intermuscular lipomas were in the forearm (Fig. 3 A-B). The fat had a peculiar milky appearance. No lymphatic cysts were found, with the exception of

FIG. 2 (Path No. 58529).—Roentgenogram of the affected arm showing the irregular widening and exostoses on the ulna. The bone is overlapped by large tissue shadows.

some small, dilated, lymphatic spaces, not true cysts, in the upper arm.

The histologic studies revealed fat cells of the adult type. An increase of the fibrous reticulum was found at the margins of the tumor. No xanthomatous or myxomatous areas are found in the fat, or any changes which might suggest that malignant changes were occurring. Dissection of the nerves revealed no sheath tumors. The nerve trunks were broadened and flattened by compression of the fat masses. Dense, osseous material projected at certain points from the shafts of the ulna and humerus. Microscopic study of these bony protuberances revealed trabeculae, such as is seen in normal adult bone.

Approximately 100 grams of fat were removed from the tumor in the fresh state. This tissue was placed in 95 per cent alcohol and forwarded to Dr. J. A. Morrell, of

DIFFUSE LIPOMA OF UPPER EXTREMITY

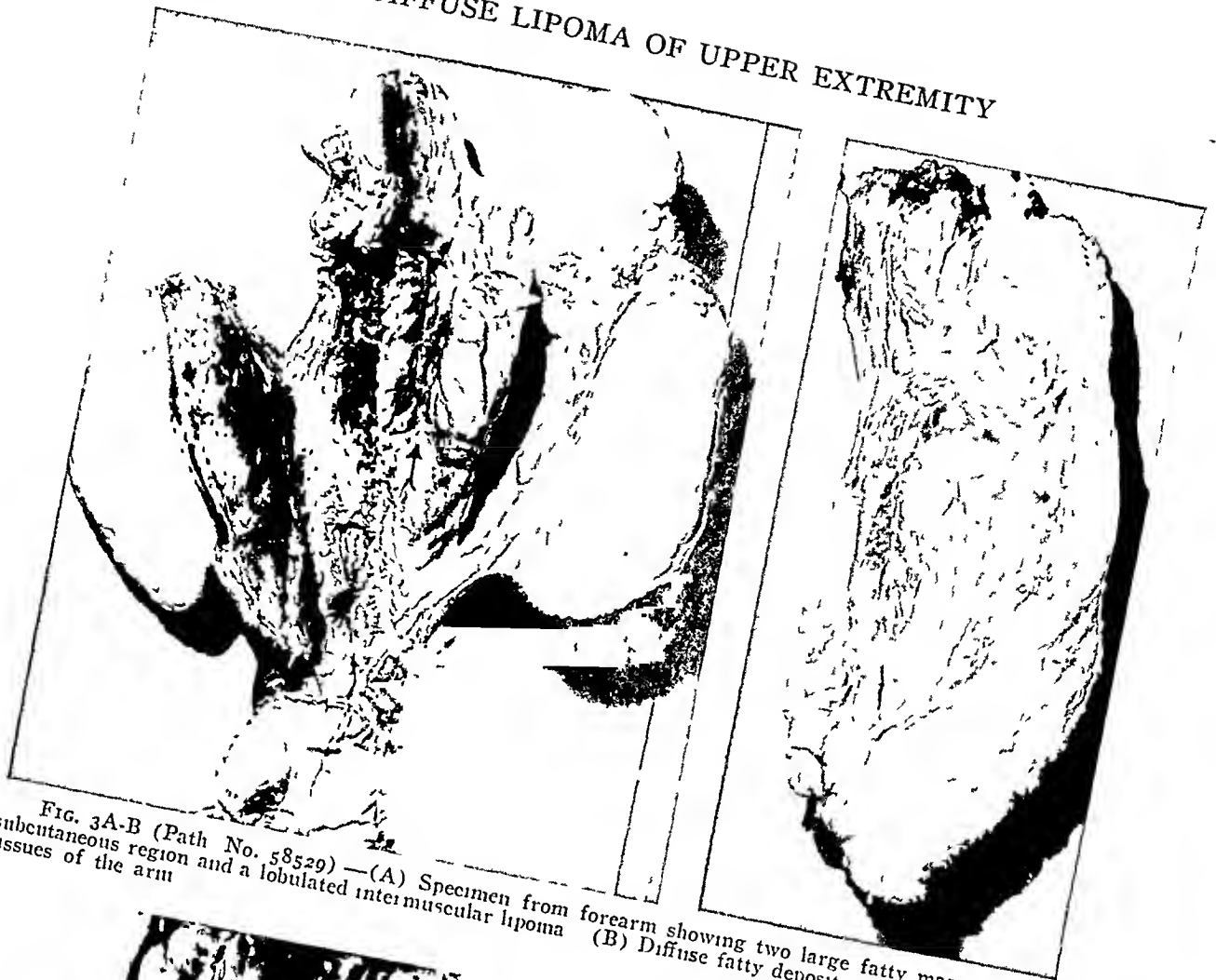


FIG. 3A-B (Path No. 58529) — (A) Specimen from forearm showing two large fatty masses in the subcutaneous region and a lobulated intermuscular lipoma (B) Diffuse fatty deposits in the subcutaneous tissues of the arm



FIG. 4 (Path. No. 58529). — Photomicrograph showing the adult character of the fatty substance in the tumor and the increase of the stroma. This tissue on bio assay yielded 10 rat units of Prolan (A and B) per gram.

E. R. Squibb and Sons, through whose kindness a bio-assay of the material was made. This revealed 10 rat units of pituitary or anterior pituitary-like hormone (Prolan A and B) per gram of desiccated tissue—approximately 5,000 rat units per pound. This is approximately equivalent to 110,000 mouse units per kilo. The blood is positive for prolان during pregnancy in the mare, cow and human beings. The maximum mouse units per liter of blood in pregnancy are given as 10,000. Zondek¹ considers 50,000 mouse units per liter of urine in pregnancy as abnormally high. The following table indicates the number of units of oestrin and Prolan A and B found in the blood and urine during pregnancy in woman and the mare (Table II):

TABLE II

Hormone Content per Liter of Blood and Urine in Pregnancy in Human and Mare

	BLOOD			URINE		
	Oestrin Mouse Units	Prolan A Rat Units	Prolan B Mouse Units	Oestrin Mouse Units	Prolan A Rat Units	Prolan B Mouse Units
Woman.....	600	15,000	10,000	12,000	20,000	10,000
Mare.....	800	2,000	1,000	100,000	800

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FRACTURE OF THE STERNUM

JOHN B. HARTZELL, M.D.

DETROIT, MICH.

FRACTURE of the sternum is an exceedingly rare condition, and frequently complicated by fractures of the ribs or spine. Holderman⁴ found 62 cases in the course of 46,237 fractures of all types, an incidence of .075 per cent. He reported three cases of his own, all occurring in miners who had suffered crushing injuries. Brown's² case was jack-knifed under an automobile. Giorgacopulo³ reported a case who received a direct blow on the sternum in a fall. Stuck⁸ has reviewed the anatomy and the mechanism of the fracture, as well as the diagnosis and treatment. He reports eight cases seen at the Mayo Clinic, the result of direct blows or crushing injuries.

Rothbart⁶ reports a fracture of the manubrium in a woman who fell from the second story on her head, suffering a contusion in the occipital region. Pazzi⁵ reports a similar instance. His patient was thrown from an automobile, striking his head in the occipital region. Neither of these cases suffered any direct injury at the site of fracture. Each of the above 15 cases were treated without surgical intervention.

Alexander's¹ two cases, on the other hand, were both old fractures with deformity. Both suffered pain and dyspnea. One in addition suffered cardiac embarrassment. Open reduction was resorted to in both. Graham reports

FRACTURE OF THE STERNUM

Stahl's⁷ case, where the gladiolus was dislocated behind the manubrium. It was necessary to insert a corkscrew into the gladiolus in order to elevate into line.

CASE REPORT.—A man, 32 years old, was thrown through the top of an automobile. His chief complaint was pain in the chest. The chest was strapped and he was then brought two hundred miles to the hospital the following day. When admitted 40 hours after the accident, he was in an exhausted state, cyanotic, dyspneic, nauseated and expectorating copious amounts of bloody sputum. His temperature was 101°, pulse 120. Examination revealed a contusion of the occipital region. There was present a painful swelling over the center of the sternum, but no ecchymosis or abrasion about this, or any

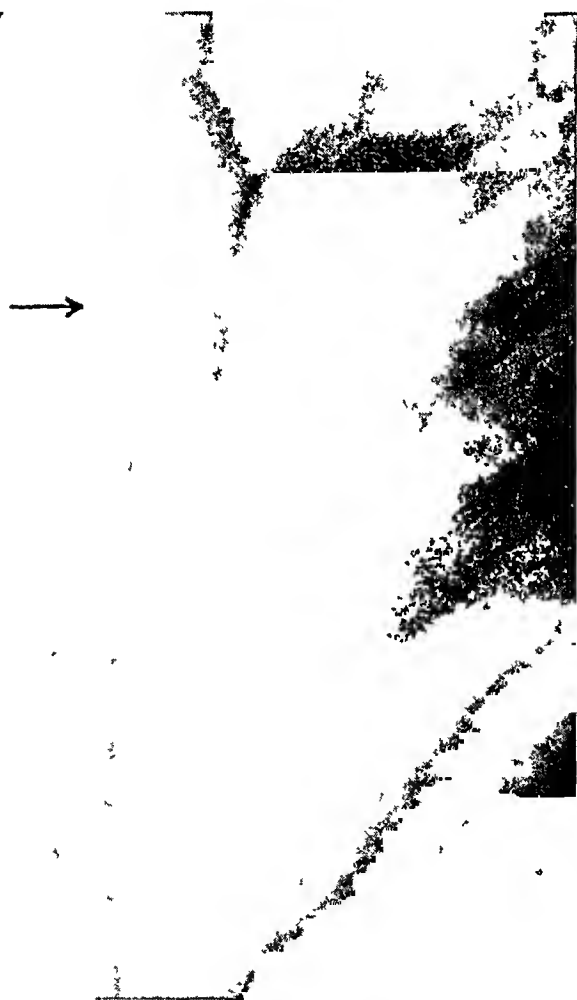


FIG 1—The sternum with the manubrium displaced posteriorly and overriding the upper border of the gladiolus.



FIG 2—The sternum after the manubrium had been elevated into alignment with the gladiolus.

sign of direct injury. The heart borders were 12 cm. to the left and four cm. to the right. There was a loud presystolic murmur at the apex and in the second left interspace. There was impaired resonance at the bases of both lungs, with moist râles. He was given morphine and digitalized. His general condition precluded any further examination or manipulation of the sternum. He was radiographed two days later. These revealed a luxation of the manubrium of the sternum on the gladiolus. The manubrium was displaced posteriorly a distance of its entire thickness and was overriding about one-half inch. There was fragmentation of the manubrium and the gladiolus at the site of their approximation (Fig. 1).

Attempts to reduce this by manipulation and hyperextension and strapping were unsuccessful. They also had such an unfavorable effect upon the patient's cardiac condition that we were forced to discontinue any such attempts.

As the patient improved he continued to suffer pain in and about the sternum which was aggravated by coughing and bending his head forward. Several other unsuccessful efforts were made at reduction. On the tenth day the patient's general condition had improved sufficiently to permit an anesthetic. Under ethylene and gas, an incision was made about three inches in length over the center of the sternum. A corkscrew was inserted into the manubrium and upper and anterior traction was made. A periosteal elevator was slipped between the two bones and used as a pry. The manubrium was lifted up into place (Fig. 2) and the periosteum and fascia sutured snugly so as to hold it from slipping back. The skin was closed with interrupted dermal sutures. A pressure pad was applied to the gladiolus, and the shoulders were strapped with a figure of eight bandage.

The patient had a stormy convalescence, but was able to leave the hospital at the end of the third week. Subsequent radiograms revealed dense callus formation at the site of fracture. Some three months later an area of necrosis appeared at the junction of the manubrium and the gladiolus. This was thought to be a small abscess containing a sequestrum. It was opened into and the cavity curetted and allowed to granulate. He has had no further trouble.

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THE TREATMENT OF BRONCHIAL ASTHMA BY DORSAL SYMPATHECTOMY

DIRECT AND INDIRECT

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THE essential factor in causation of asthma is spasmodic contraction of bronchial muscles. It is a matter of paramount importance, therefore, to ascertain the exact source and the character of bronchial innervation. The current views on this subject may be summarized as follows: The smooth muscles of the bronchi derive their nerve supply on each side from the pulmonary plexus; the latter consists of two divisions—anterior and posterior—respectively adjacent to anterior and posterior aspects of the hilum of the lung. Both the vagus and the sympathetic contribute branches to the plexus; the vagus is held to be the constrictor or the catabolic nerve of the bronchial musculature, while the sympathetic is regarded as a nerve exerting anabolic or dilator action. Both nerves have central connection with the respiratory center in the medulla. The sympathetic branches reach the plexus through the connector cells which lie in the third and fourth thoracic segments of the cord; from there connector fibers in animals pass to the stellate ganglion; in man they appear to end in all three ganglia of the cervical sympathetic. From these the excitor fibers pass to the pulmonary plexus in the cardiac branches of the sympathetic.¹ The sympathetic dilator function is thought to be manifested by the effect of adrenalin injection during paroxysms of asthma, the suprarenal bodies being closely allied to the sympathetic both developmentally and functionally.

In the light of the recent investigations this conception of the bronchial innervation cannot be accepted in its entirety. In the first place, due prominence must be given to an important anatomic structure, namely, the sympathetic thoracic chain with its twelve ganglia (occasionally only 10 or 11 ganglia are present), and numerous afferent and efferent rami. This structure is situated along the necks of the ribs, the ganglia being placed directly in front of the corresponding rib. From each ganglion seven to nine rami proceed posterolaterally to join the under surface of intercostal nerve in the space immediately

above. Some of these communicating branches are myelinated* and some are nonmyelinated. From the second, third, and fourth thoracic ganglia branches proceed medially to join directly the pulmonary plexus; from all the

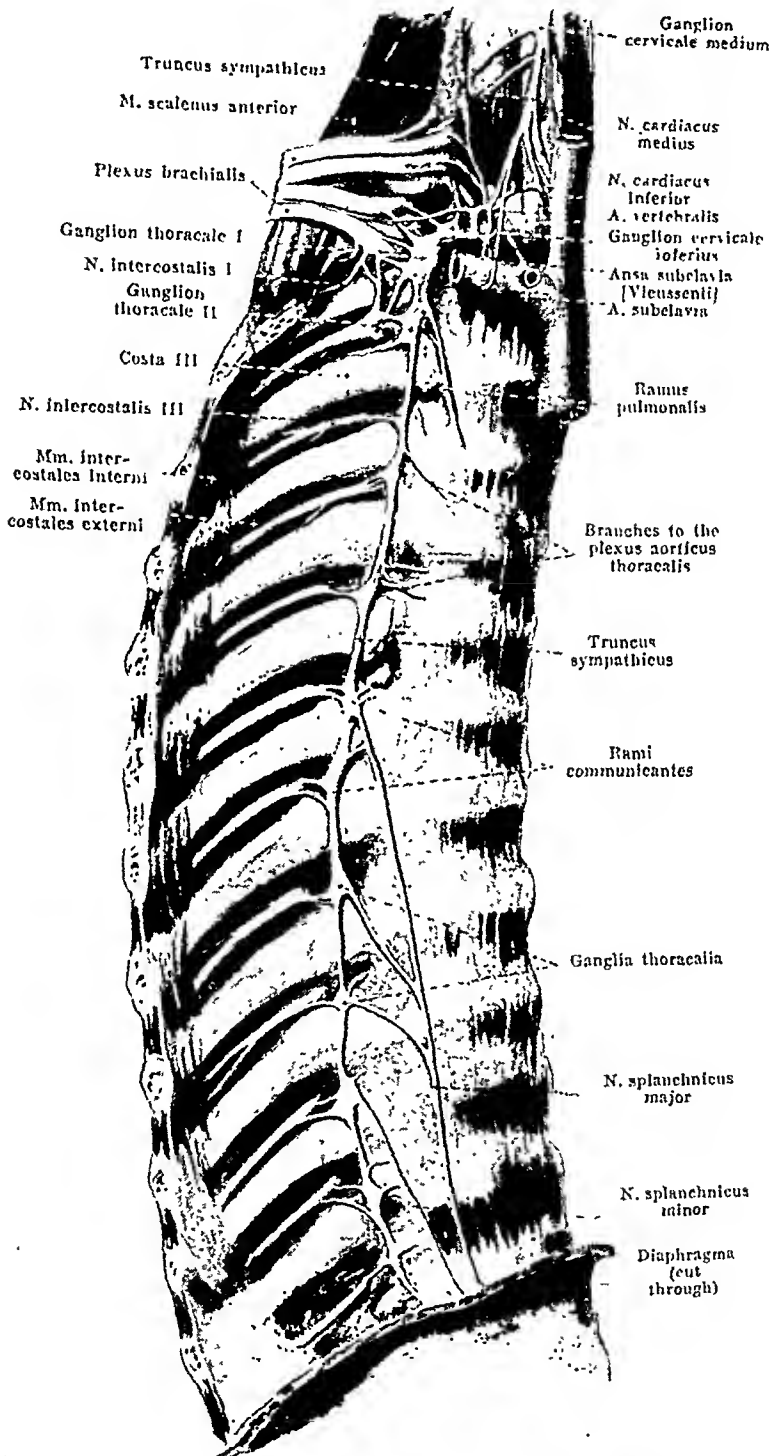


FIG. 1.—Right thoracic sympathetic trunk. Anterolateral view.
(Spalteholz.)

* The term "preganglionic fibers of Langley" is best avoided inasmuch as Kunz and others have demonstrated the existence of both ascending and descending motor tracts in the myelinated rami.

ganglia, especially the upper five, branches also proceed to the aorta to assist in the formation of the thoracic aortic plexus, and from there they pass again to the pulmonary plexus.² With regard to the cervical sympathetic, there is clear evidence that the branches conveyed by it to the pulmonary plexus are indirectly of thoracic origin. They pass from the upper six thoracic ganglia along the communicating rami above mentioned, then joining the anterior roots of the thoracic nerves they are continued in the spinal column as far as the third and fourth thoracic segments; thence they travel via the upper intercostal nerves and the thoracic sympathetic trunk³ to the cervical sympathetic ganglia and finally reach the bronchi in the cardiac branches of the latter⁴ (Fig. 1). It may be added that some fibers ascend along the main thoracic sympathetic trunk directly to the cervical ganglia without establishing synapses with the connector cells in the cord.

It will be thus seen that the whole of the sympathetic bronchial innervation is derived from thoracic source, either directly or indirectly; also that the greater bulk of it is contained in the communicating rami joining the intercostal nerves.

Further, it must be emphasized that sensory fibers are present in the sympathetic rami in addition to the motor axons, whether constrictor or inhibitory. Leriche,^{5, 17} who was very largely responsible for the introduction of periarterial sympathectomy, describes its after effects in the following way: There is an initial stage of vasoconstriction which lasts from two to 18 hours; this is followed by sudden dilatation of the artery which lasts 16 days; after that period the circulation returns to normal. Similar changes take place in the opposite limb. The regularity of vasoconstriction followed by vasodilatation with similar sequence of events on the opposite side is proof, he says, of the existence of afferent or sensory fibers in the outer sheath of large blood vessels.⁵

The sympathetic action is entirely reflex and from the practical point of view it matters little whether the sensory or motor branch of the reflex arc is severed; in neither case will exciting stimuli provoke any response. Even if one considers an ordinary skeletal reflex like a knee jerk, one realizes that motor action can never take place unless the sensory apparatus is preserved; where the latter is destroyed, as for instance in *tabes dorsalis*, the reflex cannot possibly be elicited.

On the other hand, one may hope by the destruction of the motor arm of the reflex arc to inhibit sensation of pain. Thus, for instance, severance of the upper sympathetic cervical trunk, which is a purely motor nerve, has been practised very widely for the relief of *angina pectoris*.⁶

It is important to note that all the sensory or afferent dorsal sympathetic pulmonary fibers are contained in the communicating branches passing to the intercostal nerves.

Finally, the conception of the vagus being the constrictor bronchial nerve, *i.e.*, the asthmatic nerve *par excellence*, cannot be accepted without criticism. The only evidence in support of this view are the experiments of Brodie and

Dixon.⁸ They found that stimulation of the vagus nerve in animals was followed by contraction of the bronchial muscles, while stimulation of the cervical sympathetic was followed by no response. They themselves, however, admit the existence of dilator fibers in the vagus, inasmuch as stimulation of the latter after administration of muscarine and pilocarpine was followed by dilatation of the bronchi. Further, their experiments were confined to the cervical sympathetic system and not the thoracic, which is the true source of the sympathetic supply of the bronchi; nor did they exclude reflex possibilities of bronchial dilatation or constriction, following manipulations of the neck, and in addition their results were arrived at by observing the effects of forcible inflation and deflation of the lungs through the trachea and not by registering the exact degree of distension and collapse of the alveoli which is the normal course of events in respiration.

In this connection Gask and Ross⁹ very appropriately remark: "No conclusions with regard to the sympathetic system in man can be derived from the experiments on the lower animals whose sympathetic system differs in many respects from the human. Only careful analysis of the information obtained by accurate observation of patients, especially of patients on whom an operation has been performed upon some portion of the sympathetic system, will bring to light facts which can be proved by no other method of research."

The conclusions of Brodie and Dixon⁸ are not borne out by results of clinical observation. In many conditions—pathologic and operative—the circumstances so combine as to amount unwittingly to an actual experiment upon the vagus. As a typical instance, one may consider the second or irritative stage of tuberculous meningitis. The characteristic feature of this stage is slow action of the heart, as contrasted with high temperature, convulsions, carinated abdomen, *etc.*, the bradycardia being due to direct irritation of the vagus center. Yet in spite of the vagus being thus singled out and specifically irritated by the presence of pathologic exudate, bronchial asthma has never been observed. On the contrary, the respirations during this stage are free and deep—"rarely altered from the normal" (Osler¹⁰).

Again, it is a recognised rule in the course of operations on the esophagus to paint the vagus with 10 per cent cocaine; failure of this precaution, prior to handling of the vagus, was followed by dangerous slowing of the heart, but never by paroxysms of bronchial asthma.

There are also other considerations which strongly militate against the supposed constrictor action of the vagus. Fraser,¹¹ writing on surgical aspects of certain disturbances of the involuntary nervous system, particularly stresses the point that in the course of evolution the sympathetic system, being an essentially motor or constrictor structure, was acquired first, while the parasympathetic nerves, being by nature inhibitory or relaxing, were evolved at a much later date. Although he admits that in certain parts of the body the same system may contain both sets of fibers (for instance, the sympathetic is both—motor and relaxing—nerve for the large intestine from the ileocecal

valve to the lower end of pelvic colon), yet, as a general rule, he states, where the involuntary nerve supply is double the sympathetic always maintains its phylogenic constrictor function, while its parasympathetic antagonist (the vagus in the case under consideration) invariably exercises inhibitory influence.

Carmichael and Fraser¹² have demonstrated in their recent work that stimulation of the vagus results in actual liberation of acetylcholine around the vagal nerve ends; while stimulation of the sympathetic is followed by production of a substance chemically similar to adrenalin in the immediate proximity of the nerve ends. In view of the well known depressor and relaxing effect of acetylcholine on involuntary muscle it appears utterly impossible for the vagus to act as a bronchial constrictor. As a matter of fact, no lesion of the vagus—paralytic or irritative—has ever clinically been found to be accompanied by any vestige of signs of asthma. This holds equally true whatever the nature or the position of the vagal lesion—whether due to pressure of tumor or meningeal exudate, or to injury or to peripheral neuritis, and whether affecting the vagal nucleus or the trunk.

One is forced to the conclusion that the vagus is not the catabolic or the constrictor bronchial nerve, at least not in man. It follows from this, indirectly, that the constrictor fibers must perforce be contained in the sympathetic.

Morphologic considerations substantiate this view inasmuch as the sympathetic nerves are accelerators of the heart and constrictors of the alimentary canal from the pylorus to the ileocecal valve. The occurrence of signs of general sympathetic disturbance in asthma, such as polyuria, urticaria, *etc.*, indicates a state of motor irritability of the entire sympathetic system. Study of certain aberrant forms of asthma also lends color to the constrictor conception of the sympathetic. So called renal asthma, for instance, constitutes a very curious pathologic phenomenon; its occurrence and some of its features cannot be satisfactorily accounted for except on the assumption that the bronchial sympathetic fibers are endowed with contractor power: the three splanchnic nerves which form the chief nerve supply of the kidney arise from the thoracic ganglionated trunk, *i.e.*, the same structure which is connected with and is responsible for the bronchial sympathetic supply; the pulse in renal asthma is rapid—not slow as one would expect had the reflex action taken place through the vagus. The latter remark applies with equal force to the cardiac asthma, also to the other types of reflex asthma.

With regard to the action of adrenalin, it is true enough that an hypodermic injection would relieve the spasm, but it is equally certain that were adrenalin applied directly to the bronchial muscle it would produce constriction of the latter in the same way as it does in the case of blood vessels, uterus, intestinal muscle, *etc.* The action of the adrenalin must be, therefore indirect.^{13, 14}

It will be gathered from the foregoing considerations that the rationale of dorsal sympathectomy for relief of asthma is twofold:

(1) Sympathectomy is a sure method of severance of all sensory dorsal

sympathetic stimuli, thus throwing out of action the motor half of the reflex arc.

(2) It implies direct destruction of the bronchial constrictor nerves (especially those belonging to the second to sixth dorsal rami).

Technic.—There are three methods of direct and two methods of indirect dorsal sympathectomy applicable for treatment of bronchial asthma.

(1) *Anterior Sympathectomy by the Method of Royle.*¹⁵—An incision is made parallel to the clavicle; the attachment of the sternomastoid is partly severed from the clavicle; the deep cervical fascia and the omohyoid are divided after securing the transverse cervical vessels and the scalenus anticus and the phrenic nerve are defined by gauze dissection. The attachments of the scalenus to the first rib are cut through, the subclavian artery thus exposed is mobilized and retracted downwards and forwards. The fascia of Sibson is incised along the inner border of the first rib; the dome of the pleura brought into view is retracted forwards and inwards after freeing the pleura from the first three thoracic vertebrae. The lowest cervical ganglion is found on the neck of the first rib; the thoracic trunk is followed down as far as the third thoracic ganglion and at that point is cut across. All the rami are divided from below upwards until the inferior cervical ganglion is reached and the trunk is severed just below the latter.

(2) *Posterior Sympathectomy by the Method of Adson.*¹⁶—The incision is made from the spine of the sixth cervical vertebra to the spine of the fourth thoracic. The attachments of the superficial muscles of the back are cut through and the erector spinae and the splenius capitis muscles are split longitudinally exposing the transverse processes and the adjacent upper three ribs. The transverse process of the second vertebra is severed and about two inches of the second rib are removed subperiostally. The pleura is gently peeled off the necks of the first three ribs and the bodies of the upper three thoracic vertebrae. The thoracic trunk is then found on the neck of the second rib and is divided below the second thoracic ganglion and is followed upwards with division of all intervening rami to a point just above the inferior cervical ganglion where the trunk is cut across again.

Both these methods tax the patient rather heavily and they imply severance of sympathetic supply of all the other thoracic organs as well as of the rami joining the brachial plexus.

(3) *Posterior Rami Section by the Method of Leriche.*¹⁷—The approach is on similar lines to that of Adson but the level of the operation is lower down. The incision is made close to the spine two spaces above and below the selected interspace; the muscles are split longitudinally and the articular and the transverse processes with the costal tubercle of the corresponding rib are exposed. The transverse process is severed at its base; the intercostal nerve of the space is retracted upwards and the rami are recognized as tense threads entering the under surface of the nerve; they are sectioned one by one. This method is obviously limited in its application and is suitable only for comparatively mild cases.

(4) *Destruction of the Rami by Injection of Absolute Alcohol*.¹⁸—The procedure is as follows: A point is selected 4 cm. away from the spine, preferably in the third or fourth interspace; the lower border of the rib is felt by the tip of the finger and the needle is introduced directly to the inferior margin of the rib; from this point the needle is directed 45° inwards, forwards and downwards to the depth of about 2 cm. Every precaution is taken to guard against perforation of the pleura; the needle is now connected with a syringe containing 2.5 cc. of absolute alcohol and the latter is injected by a series of small spurts. Occasionally the transverse process is unusually bulky and obstructs the desired position of the point of the needle; the latter must be then directed in such a way as to pass immediately in front and below the process; should that be found impossible the space immediately above has to be injected instead. As a rule, four injections, one a week, are given followed after a month's rest by another series of four, should any trace of asthma still persist. There is rarely any radical improvement until after the second or the third injection. The first injection is usually associated with a good deal of shock, necessitating a few hours' rest in bed.

ABBREVIATED CASE REPORTS

CASE I.—Miss B., aged 22. Subject to bronchial asthma since age of six; unable to pursue her studies; attacks temporarily relieved by morphia gr. $\frac{1}{4}$. Some improvement after course of autogenous vaccine. Four injections of absolute alcohol into the fifth and sixth right interspaces and fourth and sixth left interspaces. Total disappearance of asthma; no recurrence for the last two years.

CASE II.—Mr. A., aged 64. Intractable asthma of twelve years' standing; forced to give up business. Resection of septum three years ago with alleviation of symptoms but with no relief from nocturnal attacks. Three injections of absolute alcohol in both third interspaces and the fifth right space. Marked improvement after second injection. Complete cessation of asthma for the last seven months.

CASE III.—Mr. R. T., aged 31. History of severe asthma of four years' duration. No relief from morphia, adrenalin, peptone or autogenous vaccine. Dyspnea almost unbearable. Absolute alcohol injection into the third and fourth rami on each side; great improvement after the second injection. Complete disappearance of asthma; absolutely free for the last three and one-half years.

CASE IV.—Miss W., aged 61. Long history of bronchial asthma; emphysema of the right side with collapse of the left lung. Nine injections of absolute alcohol spread over a period of eight months. Entire disappearance of asthma; no return for the last twelve months.

CASE V.—Mr. C., laborer, aged 49. "Incurable" bronchial asthma since age of 12; never entirely free; unable to follow his employment for any length of time. Five absolute alcohol injections given at weekly intervals. Has been perfectly free from asthma for the last two years.

(5) *Destruction of the Upper Portion of the Thoracic Ganglionated Trunk by Injection of Absolute Alcohol*.—Although the third and fourth thoracic segments are anatomically placed opposite the spines of the first and the second thoracic vertebrae, the bulk of their efferent fibers pass to the fourth and the fifth thoracic ganglia and the upper thoracic trunk via the third and fourth intercostal nerves¹⁹; the upper thoracic trunk, therefore, can be

effectively attacked either in the third or the fourth space, preferably in the third. Either novocaine or gas-oxygen anesthesia can be employed. The technic is as follows: the patient's spine is strongly arched backwards with the scapulae forcibly retracted so as to bring the selected rib (the fourth or the fifth) as near the surface as possible. The upper and lower costal margin are ascertained, bearing in mind that the plane of the junction between the manubrium and the gladiolus sterni (Ludwig' plane) is on the level of the disk between the fourth and the fifth thoracic vertebrae; at a point about three cm. from the middle line a sharp solid cutting needle is introduced down to the lower border of the rib and is directed 50° forwards, inwards and downwards until the transverse process of the corresponding vertebra is felt; the upper margin of the rib is then followed by the finger tip to a point directly opposite the level of the process. A strong needle of the lumbar puncture type but of shorter length is now introduced on the slant from below so as to strike the upper margin of the rib immediately under the finger tip. The needle is so placed that its point and the aperture lie immediately in contact with the upper border of the rib. The needle is now cautiously pushed upwards, inwards and forwards closely hugging the upper margin of the rib for a distance of about two and one-half to three cm. Although perforation of the pleura appears almost inevitable experience shows that it is easily avoidable provided the needle is closely applied to the upper boundary of the rib slightly on the posterior plane. When the needle has traversed about two and one-half to three cm. of the neck of the rib it is rotated to an angle of 90° —the orifice of the needle is now directly behind the thoracic trunk. Precautions are taken again to ascertain that the pleura is intact; one cc. of absolute alcohol is slowly injected and the needle is withdrawn. Roentgenographic screen may be used as an adjuvant to make the position of the needle certain. Should the pleura be punctured during the manipulation, no harm follows in view of the valvular character of the opening. The same procedure may be adopted for the third and the second interspaces but the maneuver is more difficult on account of the greater depth of the ribs. This method is rather a major undertaking when compared to the preceding one⁴ but it has the advantage of reducing the total number of injections to two.

ABBREVIATED CASE REPORTS

CASE I.—Mr. J., aged 42, dentist. Severe spasmodic bronchial asthma of three years' standing; cardiac dilatation; totally incapacitated for last eight months. Autogenous sputum vaccine tried with no success; had been advised to give up practice. Injection of absolute alcohol into the upper thoracic trunk above the level of the fourth rib on both sides under gas-oxygen anesthesia. Gradual disappearance of asthma; chest entirely free in about a month after the injection; general condition much improved, the heart normal. No recurrence of asthma for the last six months.

CASE II.—Mr. W., aged 35. Subject to bronchial asthma for last three years; forced to give up work; unable to sleep; great dyspnea. Injection of alcohol into the left upper trunk above the level of the fifth rib under local anesthesia; pleura inadvertently punctured on the right side—injection postponed. A week later the right side injected at the same level also under local anesthesia. Complete freedom from asthmatic attacks in about six

weeks after the second injection. Perfectly free for the last eight months, gained two stone in weight.

CASE III.—Miss L., aged 37. Severe bronchial asthma since age of seven; "spent the life sitting and gasping for breath." Under local anesthesia the right upper thoracic trunk injected above the level of the fourth rib; the same procedure ten days later on the left side. Great improvement after the second injection; has not been troubled with asthma since (for the last four months).

Generally speaking, the indirect methods, *i.e.*, based on absolute alcohol injection, are preferable to the open sympathectomy for the following reasons: the procedure is infinitely quicker, the risk practically nil, the condition of the patient is usually such as to preclude any direct operative interference; furthermore, total abolition of the sympathetic control is undesirable on account of the danger of subsequent development of bronchiectasis.

In the writer's series of 23 cases treated by absolute alcohol injection, complete relief was obtained in 75 per cent with varying degrees of improvement in the remainder. All the cases were of long standing intractable asthma. Eighteen cases were treated by Method 4 (13 with complete relief) and five by the Method 5 (complete relief in four cases). The resistant cases were chiefly those where emphysema and collapse of the lung were marked features. Perforation of pleura took place on three occasions with no serious consequences.

SUMMARY

(1) There is sufficient theoretical, pathologic and clinical evidence to show that the dorsal sympathetic nerves, especially the second, third, fourth, fifth and sixth rami, contain both contractor fibers to the bronchial musculature as well as sensory bronchial fibers.

(2) Both the rami and the thoracic trunk are accessible either for neurectomy or for neurolysis by absolute alcohol; the rami—immediately below the points of junction with the intercostal nerves, the trunk—above the level of the neck of the fourth rib.

(3) Bronchial sympathetic neurolysis by absolute alcohol has resulted in complete relief in 75 per cent of cases of severe intractable asthma treated.

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MESENTERIC VASCULAR OCCLUSION

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MESENTERIC vascular occlusion was first described in 1834 by Tiedeman. In 1847, Virchow described the pathology in detail. The clinical aspects of the subject were first brought to medical attention by the researches of Kussmaul and Gerhardt in 1863, and by those of Litten in 1875. Shortly thereafter Cohnheim, Cohn and others also published the results of their experimental and clinical investigations. Welch and his associates contributed to the knowledge of the pathology and reviewed the subject up to 1900. In the last 30 years numerous excellent papers have brought the subject more fully before the medical profession. Jackson, Porter and Quimby in 1904, Trotter in 1913, Ross in 1931, Loop in 1921, Larson²⁶ in 1931 and Meyer in 1931 are only a few of the outstanding contributors. There are also many case reports, most of which submit a successful operation.

Brady⁴ stated that up to 1921 about 500 cases had been reported with only about 35 recoveries. Meyer³³ reported 92 additional cases up to 1931 with 39 recoveries. This is not as complimentary to recent medical knowledge as it seems, as there undoubtedly are a great many fatal cases which have not been reported.

Occlusion of the mesenteric vessels may result from four main causes according to Cokinis (quoted by MacCornack²⁸). These are: (1) By trauma. (2) By external pressure. (3) By embolism and thrombosis. (4) By inflammatory or degenerative obliteration of their lumens.

The two most common causes are thrombosis (arterial and venous) and arterial embolism.³² In arterial occlusion any affection that predisposes to thrombotic formation is of etiologic importance. Endocarditis, atheroma of the aorta, and arteriosclerosis, especially of the mesenteric vessels, are common causes.

Connors⁸ states that he feels that arterial thrombosis in a manner similar to coronary thrombosis occurs all over the body. Arteriosclerosis is common in the mesenteric arteries and he believes that thrombosis, especially of the smaller arterial branches, is of much more frequent occurrence than its clinical recognition. Cawadias⁷ reports a case with intermittent claudication for six years followed by angina pectoris with final thrombosis of the mesenteric vessels. Scherk⁴⁰ reports a case in which he feels the condition was caused by repeated attacks of lead poisoning causing arteriosclerotic changes leading to occlusion. Recently thrombo-angiitis obliterans has been reported as an important factor by Averbuck and Silbert.²

In venous thrombosis the condition may be primary in the mesenteric

veins and ascend into the larger radicals; or the reverse process may occur.³² "Of especial importance in primary occlusion are intestinal changes that permit entrance of bacteria into the vascular channels such as enteritis, the puerperal state, phlebitis, appendicitis, pelvic disease and other suppurative conditions of the peritoneal cavity."¹⁶ Hepatic disease, pyelophlebitis, syphilis and other conditions causing portal stasis or obstruction are mentioned as causes of secondary or descending thrombosis.¹⁶ Larson (cited above) in a report of 36 autopsies found hepatic disease in 25 per cent. Venous thrombosis has been known to follow arterial embolism apparently because of the stasis thus produced.

The following reasons are usually given as the cause of the preponderance of superior mesenteric artery lesions: (1) It is larger than the inferior (about three to one). (2) It comes off above the inferior. (3) It comes off almost parallel to the aorta while the inferior comes off nearly at right angles. As a result it is more likely to intercept an embolus. The decrease in the size of the vessels in the lower ileum due to the numerous secondary loops may also play a part.

Physiology and Pathology.—Why does gangrene occur in the face of an apparently profuse blood supply? It seems that the vessels above and below should be able to carry on the work. That this is possible is well demonstrated in a case report by Chiene.³ In a woman 65 years old with arteriosclerosis there was a complete fibrous obliteration of the superior and inferior mesenteric arteries and the celiac axis so that the entire bowel was cut off from its usual blood supply. This, without evident symptoms. The condition was noted at an autopsy.

Referring to occlusions of the superior mesenteric artery, Faber³⁵ states that the inferior mesenteric is a small vessel and is unable to take up the function of the larger. One infers from this that in occlusions of the inferior, the superior might help out simply because of its size. Boyd³ states that the sudden anemia produced by an acute blockage of a branch of an artery sets up so violent a spasmodic contraction of the musculature of the bowel that the part becomes isolated from the neighboring circulation. This spasm aggravates the anemia to such a degree that the death of the affected segment of the bowel results very quickly. The spasm would of course depend on the extent and the rapidity of the occlusion, thus at once dividing the condition into an acute and chronic type. A slow extensive occlusion might be compensated while a small sudden clot might cause infarction. The pathology involved is the same no matter what the cause or part of the bowel, providing the occlusion is large enough to cause impairment of circulation to the part (Cohnheim).

Trotter reports three per cent mesenteric infarcts as being anemic, but pathologically according to Boyd³ the infarct is always hemorrhagic. The area supplied by the vessel, if the blockage is arterial, is attempted to be supplied by the arteries above and below. In small occlusions or in gradual ones

this is successfully carried out. In others only sufficient blood is brought in from the arteries to cause the part to become congested.

The portal system has a certain pressure which is kept up by the pressure in the arteries. In an arterial occlusion, the venous supply of that part immediately drops to nil. There is, therefore, less pressure here than in the portal vein and the blood stagnates instead of passing normally. The area becomes overloaded with blood which is brought slowly to it from the adjacent arteries. Welch and his associates proved that the blood really came from the arterial capillaries and not from venous reflux as might be expected. This blood cannot escape and causes a hemorrhagic infarct. In venous occlusion, the pathology is evident. The blood has no outlet and there is a retrograde thrombosis of the arteries. The part affected is thickened, dark red to almost black in color, and soon becomes gangrenous. The limits are usually sharply defined but the demarcation may be more gradual.³ The entire bowel wall is stuffed with blood, the mucosa is necrotic and may be ulcerated. The lumen contains thick tarry blood. The serous coat may be covered by an inflammatory exudate and the peritoneum contains bloody fluid. There may even be general peritonitis. The mesentery is thickened and may contain large hemorrhagic patches. The veins are swollen and engorged. The glands are also swollen and may be hemorrhagic. Boyd³ states that there may be occlusion of the terminal arterioles with no signs of occlusion until the bowel is opened. In one case he found large hemorrhagic patches throughout the lower part of the small intestine with no lesion in the mesenteric vessels.

Surgical Pathology (Gross).—From a surgical standpoint the best gross description found by the writer of the appearance of mesenteric thrombosis at operation is by Loop.²⁷ (1) "Transparent, sticky, peritoneal fluid, amber or blood tinged, and without coagulated lymph." (2) "Cyanosed, plum colored, soggy, edematous intestine, with glistening peritoneum free from adhesions, its lumen relaxed (not distended) to large caliber, lying inert within the abdominal cavity, with no tendency to crowd out of the incision, held down by the weight of the fluid in its lumen but containing little gas. The mesentery forms a thick doughy mass dragging down over the pelvic brim as though adherent." Actually it is delivered with ease. Other writers have referred to the bowel as resembling a rubber hose.

Amount of Small Intestine Necessary for Life.—Flint¹⁵ states that to lose the use of more than one-third to one-half of the small intestine is usually fatal. Meyer³³ states that recovery has occurred after practically complete removal of the small intestine. Wulsten⁴⁵ reports a recovery after removal of 360 cm. and Sjoval⁴² a successful resection of 450 cm. or 90 per cent of the small bowel.

Frequency and Mortality.—Mesenteric vascular occlusions are considered to be quite unusual. Of 235 cases of obstruction, Cornell⁹ stated that there were five cases of mesenteric thrombosis with only one survivor. Koslin²⁴ reported seven cases in 185 instances of intestinal obstruction with no recoveries.

Morton³⁴ reported 105 cases of obstruction with five cases of mesenteric thrombosis and four deaths, Loop²⁷ nine cases with one recovery and Dunphy and Zollinger¹³ five cases with one recovery. The Binghamton City Hospital records show eight authentic cases with one recovery in the last ten years. Various authors have placed the mortality from 57.6⁴³ to 95 per cent.

Necessity for Surgical Intervention.—Meyer³³ states that in abdominal claudication the condition is entirely medical. From the pathology it is evident that unless there is insufficient circulation for life the condition will adjust itself. He found nine instances of spontaneous recovery in 92 cases. In six of these exploration alone was done. Rost,³⁸ Echemendes and Garcia,¹⁴ and Morton³⁴ also report similar cases. Abrams¹ reports one which was diagnosed mesenteric occlusion and operated. On opening the abdomen not enough pathology was found to warrant surgical intervention. Unfortunately, in this case the condition progressed to infarction and a fatal termination. This emphasizes the border line between medical and surgical treatment.

The writer believes with Connors⁸ that occlusion of small branches of the mesenteric vessels are relatively frequent. They cause symptoms of acute abdominal pain and partial obstruction which clear up within a short time. Such a history is not infrequently obtained from old arteriosclerotic individuals. Kaufmann²³ states that in annular infarcts of the terminal mesenteric vessels ileus may develop. In the absence of actual data this must be submitted as a hypothesis only.

All, however, are agreed that when actual gangrene of the bowel occurs the condition is surgical and the mortality 100 per cent if left alone. The difficulty lies in estimating where the dividing line is as evidenced in the case cited above.¹ Operation before demarcation has occurred may be useless because; (1) There may be nothing to see and (2) the extent of the involvement cannot be accurately determined. Progressive involvement after resection would seem to suggest either too early operation or too little resection. The optimum time for operation would be at the time demarcation is complete and before absorption has taken place. Since most cases are not diagnosed, this point is of academic interest only.

The main point is, when possible, to remove all the affected bowel and all the affected mesentery with enough viable tissue to prevent recurrence or progression of the pathology.³³ The type of procedure will vary from either a drainage, or simple exteriorization of the bowel, to resection of the affected part with union of the severed ends. The condition of the patient, the amount and part of the bowel involved and the skill of the operator will determine the technic. A table has been made of cases of living patients compared to the same number of deaths. These cases were picked at random in literature and whenever possible the fatalities were taken from the reports of surgeons submitting recoveries. Thus the question of the ability of the operator is to some extent removed (Table I).

TABLE I

Mesenteric Vascular Occlusion—Comparison Operative Cases

Name	Age	Sex	Amount Bowel Removed	Alive	Dead	Acute	Chronic	Procedure
Frank, Louis ¹⁶	12	M	15 inches		*		*	End-to-end
	10	M	2 feet	*		*		End-to-end
Brady, Leo ⁴	48	M	52 inches	*		*		Exterioriz.
	45	F	30 inches	*		*		Lateral anastomosis
	31	F	60 inches		*		*	Side-to-side
	42	F	..	*		*		Side-to-side
	45	F	..		*		*	Side-to-side
	24	F	18 inches	*		*		Side-to-side
Desplas, B. ¹²	32	M	60 cm.	*			*	Resected with button
Warnshuis, Fred C. ⁴⁴	50	M	2 feet	*		*		Side-to-side
Cowles, Andrew ¹⁰ . . .	18	F	3½ feet	*		*		Side-to-side
Loop, Ross G. ²⁷	35	F	5 feet		*		*	Side-to-side
	29	M	4 feet		*	*		Enterostomy
	56	M	4 feet		*	*		Enterostomy
	35	F	5 feet		*		*	Side-to-side
	47	F	8 feet		*	*		Resection
	46	F	18 inches	*		*		Side-to-side
Bruns ⁵	11	M	16 cm.	*		*		End-to-end
Jones and Clark ²¹ . . .	50	F			*	*		Exploratory
Wulsten, J. ⁴⁵	64	M	360 inches	*		*		Side-to-side Anastomosis
Carlson, Guy W. ⁶	58	M	5 feet		*		*	End-to-end
Echemendes, Y. ¹⁴	16	F	..	*			*	Exploratory
Gregoire, Ray. ¹⁹	69	M	..		*		*	Exterioriz.
McGuire, S. ³¹	27	F	7 feet 4 inches	*			*	End-to-end
	46	F	4 feet 6 inches	*		*		End-to-end
Smith, W. ⁴³	32	F	15 inches ileum	*		*		Exterioriz. Double barrel stoma.
Sjovall, S. ⁴²	44	F	90% 450 cm.	*		*		End-to-end
Olivcrona, H. ³⁶	73	M	3.4 cm.		*	*		End-to-end
Zeno, A. ⁴⁶	50	M	4 feet 6 inches		*		*	End-to-end
Reed, Leo B. ³⁷	50	F	..	*		*		Laparotomy
Jopson, John H. ²²	28	F	6 inches	*		*		Exterioriz.
	50	M	..	*		*		Exploratory
Despard ¹¹	25	F	..		*		*	Resection
Mason, J. M. ²⁹	35	F	65 inches	*		*		Resection
								End-to-end
McCornack, R. L. ²⁸ . .	40	F	..		*	*		Enterostomy
	40	F	..		*	*		Exploratory
	41	M	17½ cm.	*			*	Exterioriz.

TABLE I (continued)

Name	Age	Sex	Amount Bowel Removed	Alive	Dead	Acute	Chronic	Procedure
Green, John R. ¹⁸	42	F	40 cm.	*		*		Resection
Lang, W. H. ²⁵	60	F	14 inches	*		*		Side-to-side
Rycroft, B. W. ³⁹	54	M	Entire small intestine		*	*		Exploratory
Morton ⁴³	55	M	24 inches		*		*	Ileocolostomy
	70	M	30 inches		*		*	End-to-end
	28	M	..	*			*	Enterostomy
Binghamton City Hos- pital:								
Case 1.....	67	M	120 cm.		*	*		End-to-end
Case 3.....	73	F	30 inches		*	*		Exploratory
Case 5.....	34	M	140 cm.		*	*		Side-to-side
Case 6.....	42	M	2½ feet		*		*	Enterostomy
Case 8.....	48	F	39 cm.	*			*	End-to-end
				Dead 24		Alive 24		
				Acute	Chronic	Acute	Chronic	
<i>Procedure</i>	12	12		17	7	Total	Dead	Alive
Exploratory.....	4	..		2	1	7	4	3
Enterostomy.....	3	3		..	1	7	6	1
Side-to-side.....	2	4		7	2	15	6	9
End-to-end.....	2	3		5	2	12	5	7
Exterioriz.....	1	1		3	..	5	2	3
Exterioriz with Resect. ..	..	1		..	1	2	1	1
	—	—		—	—	—	—	—
	12	12		17	7	48	24	24
Operated—48	Acute—29		Chronic—19					

In the procedures above, enterostomy above the united ends was also done in many cases. Percentages are omitted as misleading and of no value in this small series.

Symptomatology.—Connors⁸ states that pain followed by fever and leukocytosis occurs in thrombotic conditions of the heart. He suggests that the same symptoms must occur in thrombotic conditions elsewhere in the body. Meyer³³ reports pain as occurring in each of the 92 cases where intestinal changes occurred. The leukocyte count in 20 of 23 cases where it was taken was above 18,000. "The increase is rapid and occurs very soon after the onset of pain. Only two findings, abdominal pain and high leukocyte count, were constantly associated. The temperature ranged between 96° and 101° F." Connors⁸ statement that some degree of fever and leukocytosis are present

at some stage of the condition seems well taken even in the face of apparent afebrile cases. There certainly would be fever when gangrene occurred.

Aside from the above, the symptoms are inconstant. To quote Meyer³³ again. "Vomiting was present in 55 per cent of the cases and absent in 10 per cent. It occurred after the onset of the pain and was repeated. Nausea was present in only 20 per cent. Blood in the stools was reported in 14 per cent and absent in 8 per cent. Rigidity present in 16 per cent and absent in 15 per cent. Distention at some time in 45 per cent. The findings, except for the high leukocyte count, are essentially the same as those found in early bowel obstruction." We can add nothing to this complete and concise exposition except to emphasize that the pain may be entirely out of proportion to the physical signs.¹² Like coronary thrombosis it may at times disappear only to recur in more severe form if gangrene occurs. The condition when infarction occurs is really one of intestinal obstruction with the varying signs and symptoms of that condition.

COMMENTS ON TABLE II

Cases 1 and 2.—The presence of mesenteric vascular occlusion due to heart conditions has been emphasized since the early literature. The history of valvular lesions followed later by embolic phenomena elsewhere is known to all. Its occurrence in pregnancy is also fairly common. Report of such cases having normal uneventful pregnancies followed by embolic phenomena later are not so common. Giannone¹⁷ reports a case of mesenteric vascular occlusion very similar to Case 2.

Case 3.—Arteriosclerosis is a common cause of obliteration of mesenteric blood vessels. The appearance of two areas of occlusion at the same time is unusual. Selby⁴¹ reports a case of thrombosis of the mesentery with thrombosis of the vessels of the left foot and left arm. This was in a patient with a fibrillating heart. In Case 3 it is possible that there was a heart condition also, although there was no such history and the heart on entrance showed no apparent abnormality. Another such case is reported by Olivecrona³⁶ in a male, age 73, with hypertension but with lost compensation. Embolus was the cause of the occlusion.

Cases 4, 5, and 6.—These patients all had operative procedures.

Case 4 had repeated operations and also a question of lues. Either the procedures or the lues might have predisposed to the thrombosis. The pathologist's opinion was that the chronic obstruction had led to stasis in the mesenteric vessels with thrombosis. Referring to the history of chronic constipation of several months' duration Gregoire¹⁹ reports a similar case.

Case 5 shows a thrombosis about a year after operation for an appendix. Cowles¹⁰ reports a case 23 days after uneventful recovery for an acute appendix. Greene and Allen¹⁸ report a case with thrombosis eight months after an appendectomy.

Case 6.—An example of vascular occlusion either coincident or immediately following an acute appendix operation. Meyer³³ reported seven cases

TABLE II
Binghamton City Hospital, 1925-1933

Case Sex Age Date Physician	Onset	Pain	W. B. C.	Vomiting	Temp. Pulse Resp. on admission	Area Involved findings	Procedure	Etiology	Result
Case 1. J. G., M., 67, 62692. 1/26/31. Cunningham, J. J.	Acute 24 hrs. duration	Severe, persistent	13,000 95% Polys.	Severe, persistent	T. 99 P. 98 R. 22	Jejunum, 120 cm. Large amount bloody fluid	End-to-end plus enter- ostomy	Heart	Died in 12 hrs.
Case 2. G. S., F., 30, 34376. 7/29/25. Chittenden, A. S. Marvin, H. B.	Acute 12th day postpartum	Severe, persistent	....	Severe, persistent	T. 98 P. 90 R. 20	Entire sm. bwl., 3 ft. below duo- denum. Large amount bloody fluid	Enteros- tomy	Valvular heart, pregnancy	Died in 24 hrs. Pt. had 2 nor- mal pregnancies previously.
Case 3. V. S., F., 73, 75470. 10/11/32. Griffin, H. P.	Acute 12 hrs. duration	Severe, persistent	None	T. 101 P. 92 R. 16	2 ft. jejunum. Mod. amount bloody fluid	Exploratory	Arteriosclerosis	Died in 12 hrs. Pt. also had thrombosis in left axillary artery at same time.

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Case 4. G. S., M., 49, 73478. 7/16/33. Allerton, S. M.	Chronic several months duration	Severe, intermit- tent	Occasional	T. 97.3 P. 76 R. 20	Autopsy. 2½ ft. ileum.	None	Repeated opera- tions	Died
Case 5. W. C., M., 34, 80760. 6/5/33. Behan, W. A.	Acute	Severe, persistent	Severe, persistent	T. 100 P. 100 R. 20	140 cm. ileum term. Large amount bloody fluid	Resect. (lat.) enterostomy	Appendectomy year previous	Died in 48 hrs.
Case 6. I. H., M., 42, 72260. 5/29/32. Sneerson, H.	Acute fol. appendec- tomy	Severe, persistent	None, mod. per- sistent af. appen.	T. 98.4 P. 48 R. 16	(1) Acute gangr. retro. appen- dix. (2) Autop. 2½ ft. patchy ne- crotic ileum.	(1) Appen- dectomy. (2) Enteros- tomy	Appendicitis	Died in 12 hrs. after enteros- tomy. Mesenteric Thrombosis co- incident (?) ap- pendicitis.
Case 7. A. C., M., 50, 59260. 7/15/34. Behan, W. A.	Chronic 2 months, worse 1 week	Severe, persistent	Severe, persistent	T. 99 P. 86 R. 26	Autop. Gangr. entire sm. bwl.	None	Thrombo-angitis obliterans (Buerger's)	Died 36 hrs. after admission
Case 8. W. B., F., 48, 88306. 5/30/34. Sneerson, H.	Chronic 1 week	Intermit- tent; not severe	None	T. 99 P. 100 R. 20	1½ ft ileum, sub-ac. g. blad. Mod. amount bloody fluid	G. B. drain. End-to-end resect. with enteros.	Gall. Blad.	Recovered. Apparent recur- rence 16th day spontaneous re- covery.

following appendix operations—two of which were associated with acute appendicitis. Morton³⁴ reported one following an appendix and one found coincident with a ruptured appendix. Case 6 showed a slow pulse of 48. Desplas¹² also reports a patient with a pulse of 48. This may not be pathognomonic but a slow pulse in the face of signs of an acute abdomen in the absence of jaundice is suggestive of vascular insult. It is probable that some of the present appendicitis mortality might be attributed to mesenteric thrombosis.

Case 7.—The occurrence of vascular occlusion in the mesentery in the presence of vascular occlusions elsewhere has been demonstrated. The fact that these occlusions may be due to the same type of pathology has been brought forward by Connors⁸ and Averbuck and Silbert.² The latter state that there are only nine published cases of autopsy in patients with thrombo-angiitis obliterans and mesenteric vascular occlusion and that only Jager²⁰ found lesions which he was convinced were true Buerger's disease elsewhere in the body. Because of this, the writer has included the following pathologic report by Dr. V. W. Bergstrom, pathologist, Binghamton City Hospital:

Microscopic Examination, December 20, 1934.—These sections were especially examined for lesions resembling thrombo-angiitis obliterans. "In sections made from the area of mesenteric and bowel necrosis the vessels in general show little pathology except that many of the veins are enormously dilated with blood clot. The walls of one medium-sized vein show a moderate infiltration with polymorphonuclear leukocytes. *Aorta.*—This shows marked sclerosis with large fusiform-shaped areas of fatty infiltration in which are many cholesterol clefts. The intima is very much thickened apparently due to edema and a marked infiltration with wandering cells, mostly large and small round cells, throughout the media, and in some areas there is considerable vascular proliferation in the media. There is remarkably little inflammatory reaction in the adventitia. A medium-size artery, probably mesenteric, shows a marked more recent inflammatory cellular infiltration in all layers but more particularly in the adventitia. Here some of the branches show old fenestrated fibrous thrombi infiltrated with small round cells and masses of old blood pigment. No giant cells were noted. The internal elastic membrane of this vessel is intact throughout the section. A medium-sized vein in the same area shows a moderate amount of small round cell infiltration in the walls but no thrombosis. *Liver.*—There is a generalized chronic inflammatory process around the hepatic trinity obviously involving the veins and arteries. A large hepatic vein not associated with artery or bile duct shows considerable intramural small round cell inflammation. *Heart, Pancreas and Lungs.*—The vessels show no inflammatory reaction.

From these findings it would appear that in this case there is no generalized inflammatory condition of the arteries and veins, but that a condition resembling somewhat that described by Buerger existed in the region of the mesenteric artery, and in my opinion was the cause of the thrombosis.

Doctor Bergstrom has another case, as yet unpublished, which shows the same vascular changes all over the body. There were no thrombosed areas in this patient. Zeno⁴⁶ and Brady⁴ have also reported cases of mesenteric occlusion occurring in patients with Raynaud's disease.

Case 8.—Mesenteric occlusion following gallbladder disease is fairly common.³³ The writer is not sure whether the condition in this case was following an acute gallbladder attack or whether it was entirely a vascular affair.

It would seem as if this was a good example of a patient seen when the infarcted area was completely demarcated, but with no absorption symptoms. Medical treatment in the face of apparent progression of the thrombosis during convalescence was successful in this case.

General Résumé Cases in TABLE II.—The general signs and symptoms corresponded fairly accurately to the case reports in literature. Pain often out of proportion to the clinical signs was noted in each case. Fever and leukocytosis were present in most cases. Abdominal signs varied from none to marked rigidity. Vomiting was present in most cases, but contrary to what one would expect it was entirely absent in Case 3, in which there was gangrene of two and one-half feet of bowel. The diagnosis was made in only one case and thrombosis elsewhere suggested the true condition (Case 3). Procedures used corresponded to those reported by other writers.

Diagnosis.—The diagnosis of mesenteric vascular occlusion is rarely made. This is due to the type of pathology which may cause symptoms varying from a mild distress to a severe shock-like state resembling an acute hemorrhagic pancreatitis. Because of this fact, and the fact that detailed discussions have appeared in literature, the subject is only briefly discussed.

Mesenteric thrombosis for diagnostic purposes may be divided into two classes—Medical and Surgical. These may be subdivided into acute and chronic types with their border-line cases.

Medical Thrombosis.—By this is meant small occlusions insufficient to cause intestinal gangrene or slow occlusions in which compensatory circulation occurs. This group would include the intermittent claudication of the abdomen of Meyer.³³

Symptoms.—The only constant symptom is pain. Intestinal symptoms if present would be confined to signs of partial obstruction which gradually cleared up. Surgical intervention is useless and contraindicated in this condition. Medical thrombosis is probably almost never diagnosed and no pathologic data have been found to substantiate this entity according to Connors.⁸

Surgical Thrombosis.—By this is meant sufficient infarction to cause gangrene of some part of the bowel. The pathology in this case, whether acute or chronic, is exactly the same. The symptoms would correspond with variations according to the type and amount of occlusion. Pain out of proportion to the clinical signs is usual. Fever, leukocytosis and vomiting follow pain and in turn are followed by signs of intestinal obstruction, peritonitis and death if surgical intervention is withheld. The above may occur within a few hours or may take a long time. The condition often shows very few symptoms until gangrene takes place (Case 8). In the presence of vascular disease or signs of thrombosis elsewhere the diagnosis may be made. At other times the writer feels that the diagnosis of mesenteric occlusion could correctly only be mentioned as one of the possible causes of the condition.

The border-line between Medical and Surgical occlusions is obscure. In cases where laparotomy alone was done and the patient survived, the condition

was Medical. In the state of our present knowledge of the condition, a diagnosis of intestinal obstruction with the possibility of occlusion would seem to answer the purpose practically. Since intestinal obstruction, under which mesenteric occlusions are classified, and of which they are a very small part, is difficult to diagnose because of its manifold variations as evidenced by a mortality which is reported to be from 40³² to 60 per cent,⁴⁴ the diagnostic problem is self-explanatory. The differential diagnosis would, according to this idea, be between the conditions simulating intestinal obstruction, and has been repeatedly brought out.

SUMMARY

(1) Mesenteric vascular occlusion is of much more frequent occurrence than is generally supposed. Occlusions sufficient to cause intestinal infarction are however uncommon, but are not so rare as literature would indicate. A brief résumé of recent literature has been recorded and the chief points noted have been emphasized in the case reports. The writer agrees with Connors⁸ in his hypothesis of occlusions elsewhere in the body resembling coronary occlusions. In literature and in personal experiences the symptom complex of pain out of proportion to the objective signs, fever and leukocytosis have been demonstrated. Since slight coronary occlusions are frequently passed off as mild indigestion and at the time clear up without further signs or symptoms, it seems logical that the same condition may occur in the mesentery. Mesenteric occlusions which were found at autopsy for other causes as in Chiene's case would tend to support this view.

(2) Report of a patient with thrombo-angiitis obliterans who died with mesenteric vascular occlusion is added to the literature.

(3) Another living case is reported.

(4) The diagnosis of mesenteric thrombosis is rarely made. A diagnosis of intestinal obstruction would seem to be sufficient for practical purposes. When such symptoms occur and persist, operative interference is indicated.

(5) The mortality would seem to depend upon the time when operated. If the part is removed before too severe systemic reaction has taken place, the patient stands a good chance of recovery regardless of the procedure used. Resection whenever possible would seem to be that most commonly employed.

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PERFORATED ULCERS OF THE DUODENUM

A STUDY OF FORTY-ONE CASES

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THE writer presented in 1921¹ and 1927² 15 and 27 cases, respectively, of acute perforation of ulcers of the duodenum. Simple closure of the perforation by inversion, with or without omental reinforcement, was advocated as the procedure of choice. A concomitant posterior gastrojejunostomy seemed indicated in but a small minority of cases. To the above series, 14 additional personal cases are added, thus comprising a group of 41 consecutive cases operated upon between October, 1912, and December, 1933. All were cases of duodenal perforation and prepyloric lesions are excluded.

The first successful operation for acute duodenal perforation was reported by Heussner in 1892, although Mikulicz had advocated simple closure in 1880. For many years simple inversion closure was the technic of election. Although a majority of the postoperative cases remained well and asymptomatic, a definite group had symptoms of greater or lesser severity. Some developed real stenosis and were relieved by gastro-enterostomy. In some clinics, notably Deaver's,³ a primary gastrojejunostomy was advocated in all cases but still the end-results in certain instances were unsatisfactory. Primary pyloroplasties of Heineke-Mikulicz, Horsley and Finney⁴ were advised by others. Again a group remained "uncured." Latterly, due to the European influence of radical tendencies in gastric surgery, as taught by Finsterer, Von Eiselsberg and others, primary pylorotomy, partial and even subtotal gastrectomy is recommended in the early hours of perforation.

Acute duodenal perforation from ulcer is a relatively common pathology and, after 40 years of surgical therapy, it seems remarkable that such divergent opinions exist among the leaders of the profession. All agree that the time element is of first importance. The vast majority of cases recover if operated upon within the first 12 hours by simple inversion closure. The great question is whether perforated ulcers are cured by simple closure, will the patients remain well and asymptomatic, or is more radical surgery primarily indicated? This study concerns itself with a fair evaluation of all the facts in an endeavor to reach an unbiased opinion as to what operative procedure seems to offer the best, not only immediate, but end-results.

Anatomy and Physiology.—A few anatomic relations and physiologic functions are worthy of review. The cardiac orifice and the first part of the duodenum are fixed parts of the stomach. When empty the stomach lies transversely in the upper abdomen; but when filled it assumes a vertical shape, which is due to the descent of the prepyloric part. In accord with gravity therefore, the weight bearing part of the viscus is in the distal part of

the pylorus and that part of the duodenum adjacent thereto. This pendent portion of the stomach, which includes the pylorus, the first part of the duodenum, and the distal part of the lesser curvature, has a blood supply that is considerably less than the stomach proper. Also, in addition to this subvascularization, the mucosa is here intimately attached to the muscle layers, forming rugae.

These peculiarities of anatomic detail allow very little dilatation or contraction and the consequent rigidity predisposes more or less to traction anemia. The anemia peculiar to this locale lasts about two hours after eating and may be regarded as a potent predisposing factor for selective embolic infections, thrombosis or tissue digestion. This anemia also influences the healing of ulcers occurring in this area subsequent to operative interference.

In the process of digestion, when food enters the stomach, it becomes liquefied and mixed with the gastric juice and the sphincter at the pyloric extremity does not relax until chymification is complete. The balance between the motile powers of the stomach, as shown by the retention of its contents and their later propulsion through the orifice of pylorus, is properly maintained. These motile powers are probably segmental in each curvature.

This motility mechanism, however, is badly deranged by gastro-enterostomy. Normally the acidic chyme, when it flows into the duodenum, transforms the prosecretin into secretin and thus establishes pancreatic secretion. The churning movement of the duodenum intimately mixes the chymified food with the bile and pancreatic ferment and then passes it into the jejunum. Gastro-enterostomized patients are subject to a change that may be termed revolutionary in so far as the physiology of their digestion is concerned. Gastric contents that are improperly prepared enter the jejunum, which in consequence must do the work of the duodenum, a part of the process of digestion for which it has no physiologic fitness. The subjective and objective sequences of this digestive dysfunction may be pain, vomiting, diarrhea—in fact, the whole gamut of dyspeptic signs and symptoms. That many of the patients thrive despite this handicap only shows the adaptability of the human economy. It is nevertheless true that gastro-enterostomy performed for the purpose of relieving scar tissue obstructing the pyloroduodenal orifice is, in the majority of cases, an entirely satisfactory procedure. In such cases of obstruction there has existed for some time an altered function, both motile and secretory, mostly of the stomach, to a lesser degree of the duodenum. For that reason, one chooses the lesser of two evils and makes a short circuit, trusting to Nature's well known tendency to establish a satisfactory balance. Conversely, it is well known that in the absence of true pyloroduodenal stenosis, gastrojejunostomy is often fraught with future disaster. For several months the patient is likely to be comparatively free from symptoms, but later results may be most disappointing.

The cardinal indication, therefore, for gastrojejunostomy would be actual or organic stenosis. This form of stenosis did not obtain in the majority of the cases cited here, and from discussion with colleagues, the impression

would seem to prevail that in relatively few perforations from duodenal ulcer does real stenosis occur. Moreover, it must be remembered that Nature overcomes many apparent stenoses. This fact is well demonstrated in four cases, which were subsequently operated upon for (a) incisional hernia; (b) acute suppurative cholecystitis; (c) gastrojejuno-colic fistula and (d) subphrenic abscess. The duodenum in all four cases was restored to normal yet apparent stenoses presented at the time of perforation and in one case it was so pronounced that a primary gastrojejunostomy was added. The evidence in these four cases is convincing testimony of how completely restored to normal the diseased duodenum may become. Not only was there no evidence of scarring, but practically none of adhesions.

There are numerous cases in the literature in which subsequent exploration for other pathologies revealed that there was no trace of the old ulcer (Basset,⁵ Pannett,⁶ Lecene). There is ample experimental evidence to indicate that pyloric stenosis does not occur as commonly as supposed. Stewart and Barber⁷ performed cautery puncture of the duodenum in dogs and infolded the opening so as to practically occlude its lumen. Even this did not produce stenosis clinically or by roentgenologic studies. Eliot,⁸ in 1912, experimenting on cats, found that the constriction produced by excising two-thirds of the circumference of the duodenum failed to produce stenosis. Experimentally it is difficult to thus produce true stenosis. The writer is of the impression that should the diameter of the duodenum be reduced not more than one-half, due to the infolding of the perforation, no stenosis will obtain.

Pathology.—A better appreciation of the pathologic varieties of ulcer may help to crystallize the surgical therapy. Of the well established, easily demonstrable chronic ulcer we have ample knowledge; of the so called acute ulcer, the erosion, the ulcerating lesions which recover and disappear under medical treatment, our knowledge is meager. It is highly probable that from time to time small defects occur in the gastric and duodenal mucosa, with or without symptoms, and that these spontaneously disappear. Defects of greater magnitude, true ulcers with typical clinical findings, sometimes completely disappear under medical treatment. The so called remissions and exacerbations in these histories may be explained upon the ground of recurring new ulcers. Once the lesion has become a well established indurated type the pathologic process is prone to become progressive with little or no remission of symptoms. These true surgical ulcers present five general types:

(1) The large ulcer with much scar tissue formation encroaching upon the lumen of the duodenum and accompanied with more or less extensive extrinsic adhesions.

(2) The medium sized ulcer with moderate scar tissue infiltration, without narrowing of the lumen.

(3) The small ulcer with a nonindurated or only slightly indurated base.

(4) The acute necrotic ulcer.

(5) Multiple ulcers, including the so called "kissing" type.

Perforation may occur in any of these, and as the pathology is varied so

also are the indications for surgical repair. To dogmatically state that suture with posterior gastro-enterostomy should be employed in every instance is as illogical as to assert that simple closure will always suffice. Good surgery aims to cure the patient with the least insult to anatomic and physiologic function.

Clinically most acute duodenal perforations are those of Types 2, 3 and 4. There is a remarkable monotony of appearance to these lesions. They are simple, single, round, slightly indurated, 1 to 2 cm. in diameter, on the suprapapillary part of the duodenum (the proportion is 450 to 1) and nearly always in the first one and one-half inches of the anterior and superior surface. Those occurring at the junction of the pylorus and duodenum are probably for the most part duodenal. In these the pyloric veins are often obliterated. Much less than half of those ulcers present adhesions to neighboring structures; the gallbladder, liver, colon, stomach and omentum. Most ulcers that perforate suddenly are nonadherent to adjacent viscera, and when adhesions are present in such they may be of recent origin. Disease of the appendix and gallbladder is a frequent concomitant.

The perforation is usually from 2 to 5 Mm. in diameter, a typically punched out hole in the crater of the ulcer. If carefully examined it will be noted that the entire ulcerating portion is extruded as the result of embolism or thrombosis. The remaining peripheral induration is the protective zone that accounts for the rapid healing of the lesion after closure. The writer believes that in many cases this induration is soon absorbed and the duodenum is restored to its normal condition without any macroscopic evidence of previous disease. Thus one seems justified in stating that lesions of Types 2, 3 and 4, which form the majority of duodenal perforations, are best treated by simple closure. Similar good and lasting results obtain by cautery puncture and simple closure in nonperforated ulcers of this type. The perforation or blowout replaces the cautery.

The large ulcer, with an abundance of scar tissue induration which encroaches upon the lumen of the duodenum and which usually is adherent to neighboring organs, presents a different pathology and demands appropriate surgical therapy. Such lesions, prior to perforation, have produced a partial stenosis thereby resulting in a change in the motile and secretory functions of the stomach. The closure of these ulcers after perforation usually produces a real rather than an apparent obstruction. Consequently they present the cardinal indications for gastro-enterostomy, namely, stenosis plus a preexisting altered gastric function (pyloroplasty of the Finney and Horsley type has not proved efficacious in the therapy of these types). Furthermore, simple closure in this type seldom results in permanent cure, and the relapses after such a closure have helped to popularize primary gastro-enterostomy for all types. The treatment of the multiple ulcer type must be governed by the pathologic problem at hand.

From the above mentioned pathology, it will be noted that for practical purposes perforated ulcers of the duodenum resolve themselves into one of

two types. First, the soft lesions—the more common type—characterized (*a*) by their relatively smaller size, (*b*) by their superficial extent, (*c*) by their failure to penetrate deeply prior to the embolic or thrombotic phenomenon which results in perforation, (*d*) by the absence of dense induration, and (*e*) by lack of adhesions and encroachment upon neighboring structures. Second, the calloused type, characterized (*a*) by their large size, (*b*) by their deep penetration, (*c*) by their dense induration, (*d*) by their firm adhesions to neighboring structures, and (*e*) by their tendency to produce mechanical complications. It is the opinion of the writer that simple closure by inversion with fine chromic catgut will cure the vast majority of the first group, whereas the calloused types require in addition a primary gastro-enterostomy, or perhaps some form of pyloroplasty. The successes and failures in this series are in accord with these general principles.

Diagnosis.—The diagnosis of acute perforation can be easily made in most cases. The anamnesis of previous indigestions, often a recent exacerbation with preperforation pain of several days due to serosal involvement, the suddenness of onset, the agonizing pain, constant in character in contradistinction to the colic-like pain of appendicitis, cholecystitis, intestinal obstruction or renal colic, the vast extent and the degree of rigidity and tenderness so soon after onset, the comparatively slow pulse, slight or no febrile reaction is a familiar picture. A few points are worthy of emphasis: vomiting occurred in less than half of the cases in this series (17 cases). Rectal examination may elicit extreme tenderness soon after perforation, much earlier than in appendicitis. The symptom of shock has been overemphasized. In this series but nine were in any degree of shock. Apparently shock, when present, occurs soon after perforation and is transitory. It should also be mentioned that in stout individuals there is only moderate rigidity. Also in the transitional period passing on to true peritonitis, there is a free interval when the pain is ameliorated. One patient seen 18 hours after perforation sat up in bed exclaiming, "He felt quite well." No opiate had been administered. His abdominal cavity contained the usual amount of duodenal contents and the peritoneum was markedly injected. More than half of the cases show obliteration of liver dullness either partial or complete. It is merely a corroborative sign and is in no wise pathognomonic. The left shoulder pain, mentioned by Gibson,^{9, 10} as occasionally occurring early after perforation, occurred in three cases and is probably a pneumogastric-spinal accessory reflex rather than pain of peritoneal or anginal origin. The subdiaphragmatic gas bubble, seen in vertical roentgen ray plates, is an early diagnostic help. It is especially helpful in cases of small perforations with atypical signs. Occasionally a localized zone of tympany just below the xiphoid obtains early.

In the preperforative irritation stage, physical examination may reveal acute tenderness over the ulcer with some rigidity of the overlying muscles. This connotes a deep ulcer with peritoneal irritation and should be an indication for surgical intervention. (Case VII well illustrates this danger signal: Thus a female of 57 years for six months had typical hunger pains occurring

three hours after eating. Her examination elicited acute tenderness over the site of the pylorus and moderate rigidity of the rectus. Temperature, pulse and blood count were normal. She was put to bed and placed upon Lenhartz diet. Tenderness and muscular spasm persisted. On the eleventh day of treatment perforation occurred suddenly while she was at absolute rest.)

Treatment.—The treatment of acute perforation is immediate operation regardless of any degree of shock that may be present—as the patient's condition rapidly improves with the relief of intraperitoneal tension. A four-inch right median rectus incision is deepened down to the peritoneum. A point of practical importance is to determine the lower border of the liver. This should limit the upper angle of the incision. If a small nick is first made into the peritoneum, a little free fluid will well up into the incision, and gas bubbles erupting through this will clinch the diagnosis of perforation. The escaped contents are best aspirated, especial attention being paid to Morrison's space, the right lumbar gutter, and to the toilet of the pelvis. With moist pads the surrounding structures are gently pushed aside and the perforation sought. Fibrin deposits are an excellent guide to the point of perforation and not infrequently gas bubbles point out the way. If the perforation is obscure, slight pressure on the stomach may cause bubbles to appear. Closure of the perforation is accomplished by infolding the ulcer with fine chromic catgut reinforced occasionally with an omental tab. The expediency of a primary gastrojejunostomy is determined by the pathology. If simple closure is performed, one tests the patency of the lumen of the gut. If the tip of the little finger can be insinuated through the site of closure, there is little danger of obstruction. One then makes a search for secondary ulcers, gallbladder and appendiceal disease.

The added risk of primary gastro-enterostomy, before the advent of peritonitis, is slight in a patient whose condition during operation, as regards respiration, aeration, and circulation is good. The danger of working in a potentially infected field is more theoretical than real. The real dangers are two-fold: (1) a 2 to 3 per cent chance of future gastrojejunal ulcer formation, and (2) the late secondary sequelae which occur in some cases despite perfect technic in the hands of the most skilful. Therefore, unless the pathology is such as to demand a primary gastro-enterostomy, *i.e.*, definite obstruction, simple closure should be performed. A good practical rule is, when in doubt, do not perform a gastro-enterostomy. It can be performed later, if necessary.

If a careful peritoneal toilet be made by aspiration, there is no need of drainage except of the mural tissues. The suprapubic stab wound seldom drains, but may produce adhesions and is contra-indicated. Drainage to the site of closure is never instituted as several duodenal fistulae have resulted thereby. The slow perforations with abscess formation are best treated by simple incision and drainage. If a fistula ensues, a secondary closure with gastro-enterostomy is indicated.

Following operation the patient is placed in a semirecumbent position, given one or two doses of morphine and a 5 per cent glucose rectal drip.

Small amounts of water by mouth are permitted after four hours. On the third day, a modified Sippy diet is instituted and adhered to for its entire course. At this time, the foot of the bed is kept elevated about six inches. This is thought to relieve traction anemia upon the pyloroduodenal segment. Frequently small amounts of alkalis are administered the first two weeks. The patient is then given a light, selected, nonbulky diet with crackers and milk between meals for the next two weeks. At the end of two months, a roentgenologic examination is made. The patient is warned of the dangers of dietary indiscretions and receives medical supervision for at least six months.

The series is comprised of consecutive personal cases operated upon between October, 1912, and December, 1933. There were 39 males and two females. Although duodenal ulcers are more common in males, the relative incidence in the two sexes does not account for only 3 to 5 per cent of perforation in women. Many suppositions have been offered. White¹¹ well answers them by stating that he cannot become enthusiastic over any of these "attempts at the explanation of a very puzzling fact." The youngest patient was 21 years; the oldest 57; the average 36 years. Most large statistics reveal above 40 per cent in the fourth decade. However, there are reported cases occurring in young children and also in the aged. It is interesting to note that no case was obese (*versus* gallbladder type) and that several had been under severe mental or physical strain. Their occupations were varied and irrelevant. Twenty-seven (66 per cent) gave a typical previous ulcer history varying from a few months to 11 years. Eleven (26 per cent) presented indefinite dyspepsia symptoms. In two cases there were no symptoms to the moment of perforation. In these ulcers the evidences of inflammation and repair were absent and the picture was one of focal necrosis. Both have remained asymptomatic following simple inversion closure.

Four cases gave a history of melena, none of hematemesis. In Deaver's series of 55 cases, blood was found only twice in the stools or vomitus. In White's Roosevelt Hospital series of 62 cases only 3 per cent had bleeding. It is well recognized that bleeding ulcers seldom perforate.

Only three cases perforated within the first year of symptoms and the average duration of symptoms until perforation was 46 months. The incidence of chronic ulcers which perforate appears very small and the danger very slight.

Of the 41 perforations, 37 were acute and four slow perforations. Of the slow perforations, one presented a large abscess extending from the liver to the iliac crest. This was of two weeks' duration. Another case perforated slowly and remained localized. The third case ruptured into the lesser sac, presenting the clinical picture of biliary obstruction with jaundice. The fourth occurred in a penitentiary inmate who was under treatment for drug addiction. At first the patient received little attention as his epigastric pain was thought to be due to drug withdrawal. The writer saw him on the second day, at which time he was walking about the ward complaining of epigastric, and especially mid-lumbar pain. The abdomen was negative. Two days later

he developed upper right rectus rigidity. Temperature, pulse and leukocyte count were normal. A vertical roentgen ray examination showed a sub-diaphragmatic bubble. Laparotomy failed to reveal any pathology. The lesser sac was opened and found normal. For three days the patient remained quite comfortable. Following another attack of severe pain the patient went into partial collapse and died 40 hours later with a temperature of 105.4° . The upper abdomen was moderately distended but not definitely rigid. Autopsy revealed turbid fluid in the lesser sac and a sloughing 2 cm. ulcer on the posterior wall of the duodenum at the papillary level. Fortunately ulcers in this silent area are rare.

Of the acute perforations (37) the shortest time elapsed until operation was three hours, the longest 26 hours, the average being 10 hours plus. The temperatures averaged 99.6° per rectum, pulse 86, respiration 23. White blood cells 15,400 with 82 per cent polymorphonuclears. Cultures taken in 21 cases were all sterile, which is usual during the first 12 hours following perforation and many are sterile the first 18 hours. Of the 37 cases a correct preoperative diagnosis was made in 34. Two were mistaken for perforative appendicitis and one for acute hemorrhagic pancreatitis because of the pronounced shock, persistent vomiting and only slight epigastric rigidity.

In this series simple closure was performed in 32 cases and concomitant gastrojejunostomy in eight cases. One case, simple closure, died suddenly on the fifth day (possibly of embolism). The other death occurred in the patient explored for what apparently was a perforating ulcer, thus giving an operative mortality of 5 per cent.

One patient in whom a transverse incision was employed (1919) returned in three months suffering from an incisional hernia. During repair, the duodenum was carefully searched for the old ulcer site, it had been a soft ulcer type of one year's duration. The duodenum appeared normal. Another developed an acute suppurative cholecystitis four months postoperative, requiring cholecystectomy. The duodenum was free of adhesions and the ulcer site had disappeared.

A third case upon whom a primary gastrojejunostomy was performed, also cholecystectomy and appendectomy, remained well for four and one-half years. He then developed a gastrojejuno-colic fistula with the classical syndrome of left epigastric pain radiating to the left groin. At operation there presented a gastrojejunal-colic fistula about 2 cm. in diameter. The remarkable feature was the almost negligible pathology at the former duodenal ulcer site. There was no scarring, no induration, no stenosis and few adhesions. The procedure consisted in undoing the gastro-enterostomy, closing the gastric and colic atria and resecting three inches of the jejunum with lateral anastomosis. The patient was discharged on the sixteenth day and has remained asymptomatic.

A fourth case, operated upon 13 hours after perforation, developed a subphrenic abscess. Upon reoperation 27 days later the duodenum was restored to normal.

These four cases are highly presumptive evidence that perforation tends to cure the ulcers and that the duodenum is capable of complete restitution to normal, even though apparent stenosis obtains after closure. Twenty-four patients have been followed from one to 20 years. Of these, 18 had simple closure and six concomitant gastro-enterostomies. Of the 18 simple closures 14 (78 per cent) have remained well and asymptomatic. One required a secondary gastrojejunostomy two years later for hemorrhage and remained well thereafter. Three have digestive upsets unless a careful diet is followed. In all three the gastro-intestinal series are negative. Of the six gastro-enterostomized patients, who have been followed, only three are quite well (50 per cent). One required a secondary operation for intestinal obstruction from bands about the appendicectomy site, one had the gastrojejunostomy undone for gastrojejuno-colic fistula and the third is generally miserable with dragging epigastric pain and occasional diarrheal attacks.

In conclusion one seems justified in emphasizing the importance of reporting the end-results of the treatment of perforated ulcers of the stomach and duodenum as separate entities. The immediate results depend chiefly upon the time interval that has elapsed after perforation. Only by careful follow-up records extending over long periods can reliable statistics be obtained as to ultimate cures. Undoubtedly the duodenum is capable of complete restitution to normal even though apparent or mild degree of real stenosis obtains after closure. The end-results of simple closure in this series are much superior to those treated by gastrojejunostomy. Simple closure is the operation of choice of most surgeons.

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ENLARGEMENT OF THE GALLBLADDER

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THE normal gallbladder shadow has not been defined, nor has much attention been directed to the size and contour of this organ as shown by the roentgen ray after the administration of the dye. Before the advent of the dye method of depicting the gallbladder, everyone was concerned with the presence or absence of stone showing in the radiograph, and it naturally followed that the presence of stones was the most significant finding with the new method. Added to this, the filling and emptying of the gallbladder with the dye gradually took on significance as experience increased with this new method. During a four year study of patients with gallbladder disease at the New York Post Graduate Hospital, the combined Medical and Surgical Clinic has gradually come to realize the importance of changes in the size and contour of this organ.

In patients with typical gallbladder symptoms, definite pathology was found to be present and borne out by operative findings even though the radiograph showed repeatedly the absence of positive or negative shadows of stones and normal filling and emptying. The most important change is enlargement, for in enlargement one has a definite result of stasis, the most frequent accompaniment of gallstones found in operative specimens.

Enlargement of the gallbladder, as shown by roentgen ray shadows and in operative specimens, follows, in the main, an hypotonic and an hypertonic type. In the former, a rounded balloon type of shadow appears (Fig. 1, *a* and *b*), which, when removed, distended and dried, appears as in Fig. 2.

The latter types are elongated, tubular and pear shaped, with convolutions in ampulla and cystic duct (Fig. 3, *a* and *b*), and when removed and prepared are represented in Fig. 4.

The hypotonic type of gallbladder shadow is found in those individuals having few symptoms ascribable to the organ directly, but with the usual type of dyspepsia associated with the achylia, overweight and indolence of middle age.

The basic cause resulting in such a change in the gallbladder can be ascribed to dilatation due to the normal secretory pressure of bile in the presence of atrophy and atony in the wall of the viscus, such as is shown in specimens removed at operation.

Dilatation such as this should be harmless and produce no symptoms, were it not for the resulting stasis that is particularly important during periods of child bearing or rapid loss of weight, when the cholesterol of the bile increases and stasis of bile may result in the formation of the so-called

metabolic single cholesterol stone (Fig. 5). Such dilatation of the gallbladder as this, with or without stone, is most often found during a routine physical examination in a gouty or rheumatic individual, frequently when looking for a focus of infection in the patient with osteoarthritis. We may say here that

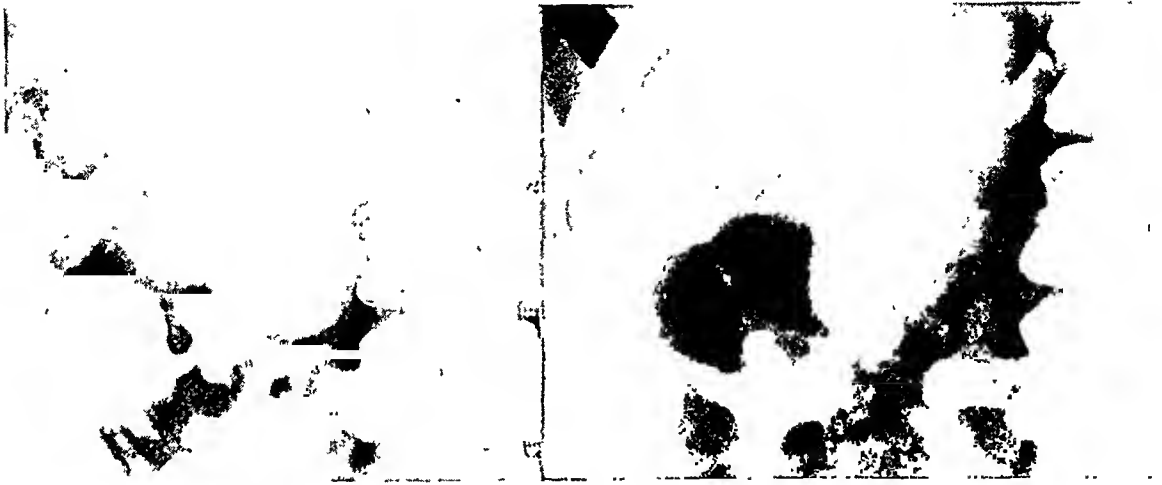


FIG. 1a.
Enlargement of the hypotonic type gallbladder, as shown radiographically.

in none of these types of patients have we found such a gallbladder to be important as a source of infection.

The surgical importance of such a gallbladder without stones does not arise, and this type of organ deserves surgical consideration only in the presence of stone. Before impaction of the stone in the ampulla surgical removal prevents this accident, which results in hydrops in the absence of infection,



FIG. 2.—An hypotonic type of gallbladder distended and dried.

and acute infectious gangrene and abscess in the presence of infection or pressure necrosis of the viscus.

From a purely surgical standpoint, the evolution and final stage of this gallbladder is shown in Figs. 6, 7, 8, 9, 10 and 11.

Fig. 6 shows a balloon type of gallbladder, thin atrophic walls, short straight cystic duct, promoting stasis.

Fig. 7.—An early impaction of a pure white cholesterol stone in a mod-



FIG. 3a.
Hypertonic type of gallbladder as shown radiographically.

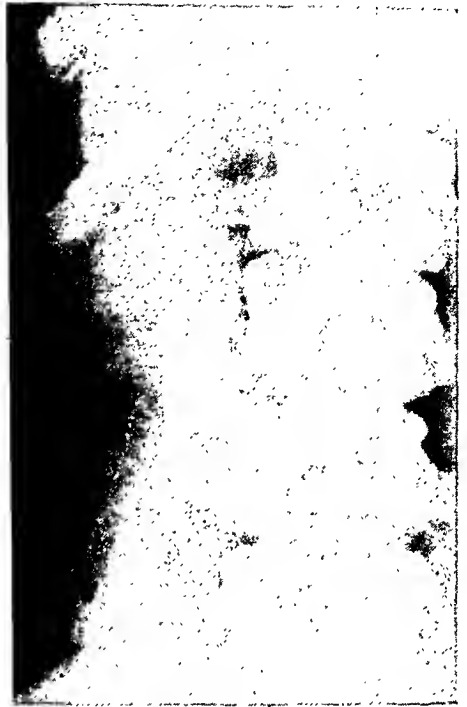


FIG. 3b.



FIG. 4.—A hypertonic type of gallbladder removed and prepared.



FIG. 5.—Dilation of the gallbladder.



FIG. 6.—Balloon type of gallbladder.

ENLARGEMENT OF GALLBLADDER

erately enlarged gallbladder with hydrops. The walls were edematous, not acutely inflamed and not infected. This specimen was removed at the first attack of impaction.

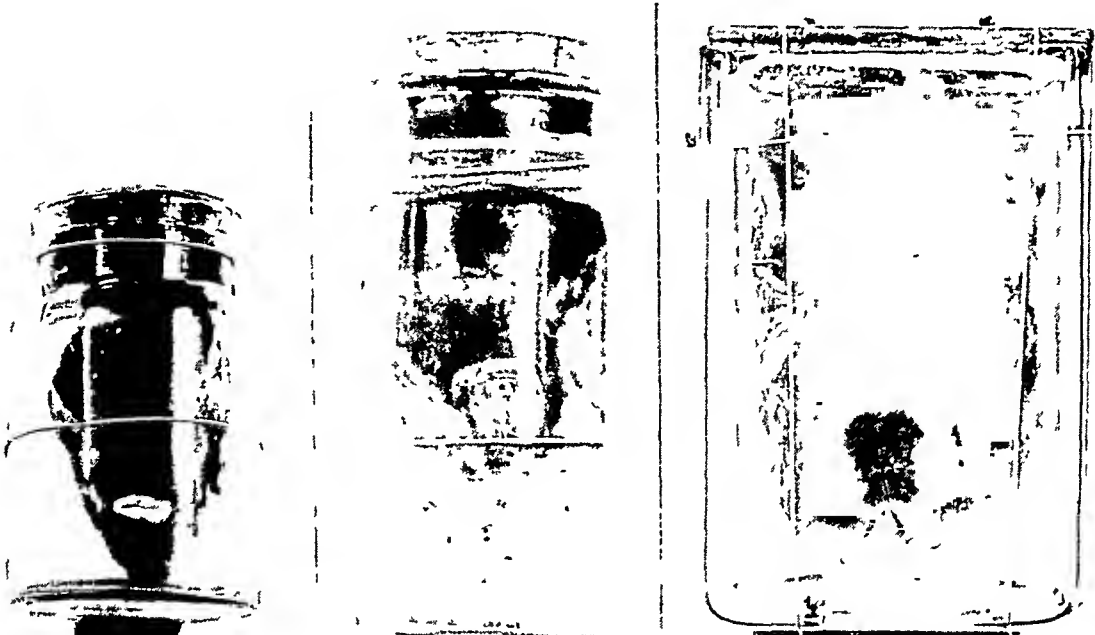


FIG 7—Impacted cholesterol stone. Edematous gallbladder. FIG 8—Pigment incrustated stone. Inflamed gallbladder. FIG 9—Enlarging stone. Fibrosis of gallbladder.

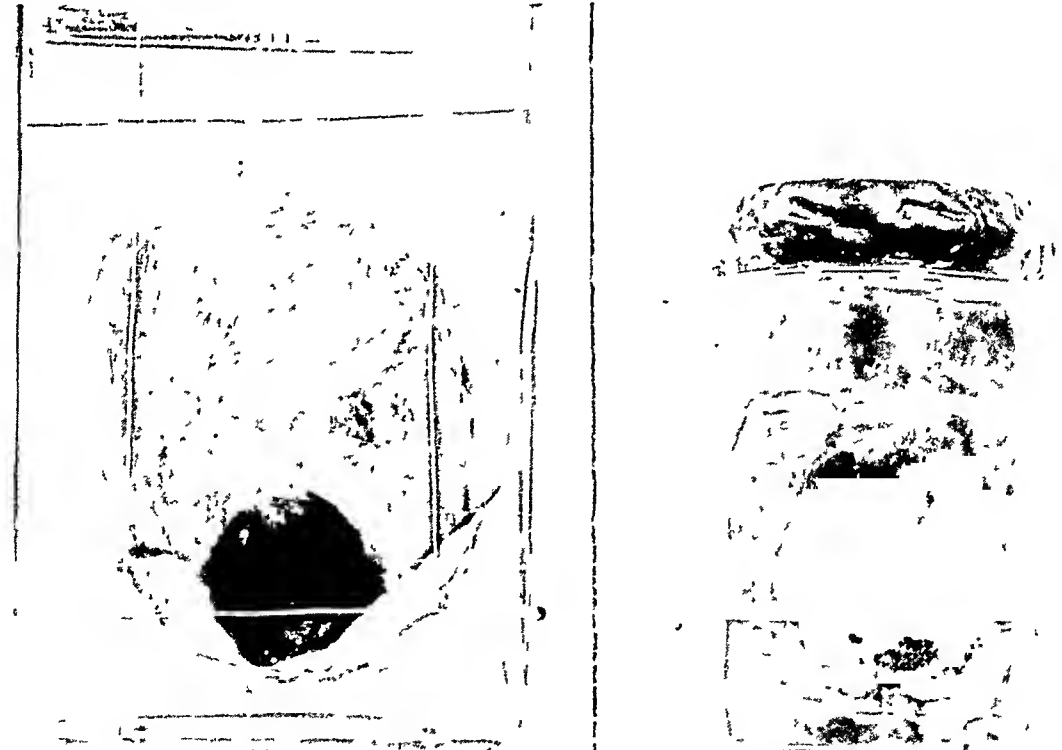


FIG 10—Enlarging stone. Fibrosis of mucous membrane. FIG. 11.—Contracture about stone

Fig. 8.—The gallbladder was larger, the cholesterol stone was discolored, the walls were edematous, inflamed and infected. This specimen was removed during the subsequent attacks of impaction and infection.

Fig. 9.—The gallbladder was large and round, the stone larger and more discolored, its wall was thickened, fibrotic, inflamed and infected. This speci-



FIG. 12.—Moderately enlarged, tubular, pear shaped, with no convolutions of the ampulla and cystic duct around the cystic artery and vein. The walls are moderately thickened.

men showed the effects of former attacks of impaction and infection, as well as the present one.



FIG. 13.—A similar enlargement with multiple pigment, calcium, cholesterol stones.

Fig. 10.—A large round gallbladder, containing a large pigment encrusted cholesterol stone. Its wall showed mainly fibrosis and thickening from chronic



FIG. 14.—Similar enlargement, similar multiple stones with impaction of a stone in the cystic duct between the valves of Heister. The cystic duct is further curved back upon the ampulla.

impaction of the stone with low grade infection leading to a purulent hydrops of long standing. Operation after acute symptoms had subsided.

Fig. 11.—The final stage. The gallbladder is small, round and contracted down to fit a large pigment encrusted cholesterol stone. Its wall was very thick and fibrous. There was little or no detritus present and the stone is finally encysted, resembling an alligator pear; the meat, the gallbladder wall, and the pit, the stone.

The hypertonic type of gallbladder shadow (Fig. 3) is found in those indi-



FIG. 15.—Further enlargement and hypertrophy, more acutely convoluted cystic duct and ampulla (the vessels do not seem to elongate as the cystic duct and ampulla do, thereby necessitating a ruffling of this region) as the attacks of impaction and increased pressure continue.

viduals having marked symptoms of pain, attacks of colic, frequently requiring sedatives long before stones can be demonstrated either by roentgen ray or in operative specimens, accompanied by the usual type of dyspepsia associated with hyperacidity, pylorospasm and duodenitis.

The basic cause resulting in such change in the gallbladder can be ascribed to enlargement due to an increase in pressure within a resisting gallbladder



FIG. 16.—The cystic duct and ampulla have curved back to accommodate the length of the cystic vessels.

wall. In the presence of hyperacidity, pylorospasms, duodenitis and spasm of the sphincter of Oddi, there should be brought to bear upon the gallbladder the full secretory pressure of the liver. Under such conditions, the viscus of normal tone should enlarge, hypertrophy, and retain its normal contour, even though exaggerated.

Dilatation, such as this, should produce symptoms of pain and colic, as has

been found to be the case, and stasis resulting in stone formation of a different type. Many families of pigment cholesterol stones are usually found in gallbladders of this type of long standing. Such gallbladders are usually found



FIG. 17.—The advent of a purulent infection with rapid inflammation, distention, gangrene and necrosis.



FIG. 18.—In the absence of a purulent infection, fibrosis of the gallbladder begins with chronic infection, the result of colon bacillus invasion.

in patients with active pain and colic that can be definitely ascribed to this organ.

The surgical importance of such a gallbladder, both with and without stones, has been very well established by the relief of colic afforded by its removal. In the absence of stones this type of gallbladder enlargement can

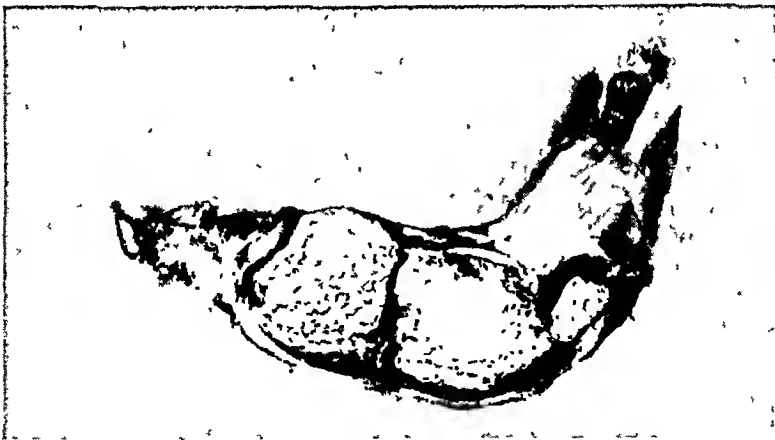


FIG. 19.—Further retraction with fibrosis and the formation of the "Black Jack" gallbladder containing little or no detritus and contracted tightly down upon the stones

be successfully treated medically by the ordinary Sippy routine of alkalinization with frequent feedings to enhance its emptying. Yet, as is frequently found in the treatment of duodenal ulcer, in this type of individual recurrences from interruption of routine make operation the simplest procedure.

However, after cholecystectomy, when the sphincter of Oddi has not been relaxed, or after tone has returned, these patients may again have colicky attacks, with dark bile obtained by the duodenal tube, crystalline sediment and every indication of an active phase of concentration and stasis in the common duct during a period of personal trouble, or other cause for hyperacidity and neuromuscular dysfunction of the stomach and duodenum. During such periods, the Sippy routine and sedatives will again be required for the relief of symptoms. Without such treatment, these patients may develop stones in the common duct during these active phases which may correspond to the activity which results in stone formation in the gallbladder before it is removed.

After the occurrence of stone, the additional pain from impaction and danger from ulceration and infection of the gallbladder make their removal one of the most clearly defined surgical indications.

From a purely surgical standpoint, the evolution and final stage of this type of gallbladder is shown in Figs. 12, 13, 14, 15, 16, 17, 18, and 19.

A further complication may occur in the evolution of this type of gallbladder when a stone of comparatively large size becomes impacted in the ampulla, causing dilatation of the cystic duct in which there are ahead of it and nearer the common duct two or three small stones that may be floated into the common duct. When removed, they present the same characteristics as those stones in the gallbladder. Four such instances have been encountered in the past one hundred patients operated upon. Therefore it is important to explore the common duct when stones are found impacted in the cystic duct.

NOTE.—The author wishes to express his appreciation to Dr. Charles G. Heyd and Dr. Edward W. Peterson for their assistance in selecting the specimens used to illustrate these observations.

THE RELATION OF CHOLECYSTITIS TO PATHOLOGIC CHANGES IN THE LIVER *

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CONTROVERSY still exists as to the relation of inflammation of the gallbladder to concomitant pathologic changes in the liver. While some believe that cholecystitis is the result of a primary hepatitis, others advance the view that the hepatic changes are secondary to the disease of the gallbladder. A third group of observers holds that inflammation of the gallbladder and pathologic changes in the liver are independent of each other. A review of the various contributions shows much which is contradictory and raises many questions for further elucidation.

Riedel,¹ in 1888, first called attention to the fact that there appeared to be an enlargement of the right lobe of the liver in cholelithiasis. This observation was subsequently confirmed by others. However, the investigation of the presence of liver pathology in acute and chronic cholecystitis received little attention until 1918. Graham,² at that time, published his observations and microscopic findings in sections removed from the liver edge near the gallbladder in thirty consecutive cases of biliary tract disease. The microscopic sections disclosed the presence of hepatitis, consisting of infiltrations of polymorphonuclear leukocytes and lymphocytes in the interlobular spaces and often a mild fatty metamorphosis of the cells. The intensity of the hepatic changes seemed proportionate to the severity of the cholecystitis. The liver in cases of chronic cholecystitis often revealed lesions typical of early biliary cirrhosis. In 1921, Peterman, Priest, and Graham³ confirmed the latter's previous observations and conclusions.

Graham's statement that cholecystitis is constantly accompanied by hepatitis, and that infection of the gallbladder results from a primary hepatitis, has been widely accepted. Tietze and Winkler,⁴ Genkin,⁵ Genkin and Dmitruk,⁶ Murayama,⁷ Pettinari,⁸ Vilardell and Llort,⁹ MacCarty and Jackson,¹⁰ Hadley,¹¹ Heilmann¹² and many others, have reported the constant presence of liver changes in diseases of the biliary tract. Judd, Nickel and Wellbrock¹³ stated that hepatitis and cholangitis occurred routinely in the presence of cholecystitis.

While many others agreed that the gallbladder lesions were accompanied by hepatitis, several have questioned which organ was primarily involved. Koster, Goldzieher and Collens,¹⁴ in a similar study, confirmed the presence

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of a hepatitis, but felt that the inflammation of the gallbladder was primary. Else, Rosenblatt and Davis¹⁵ believed that the liver was involved by direct extension from an infected gallbladder. Heyd, MacNeal and Killian¹⁶ concluded that hepatitis was almost always associated with gallbladder disease but that it might be primary or secondary.

In spite of the evidence apparently supporting the dictum that hepatitis invariably accompanies cholecystitis, other investigators not only expressed doubt as to whether the cholecystitis or the hepatitis was the primary lesion, but whether an actual relationship existed between the lesions of the gallbladder and those observed in the liver. Martin¹⁷ called attention to several pertinent facts, well known but apparently neglected in previous discussions of this problem. He pointed out that one of the main functions of the liver was the destruction and disposal of bacteria and toxic substances brought to it throughout the life of the individual. Some of these were destroyed without evident reaction, but that all forms of an appreciable reaction, from a mild to a severe hepatitis, might occur. He felt that the hepatitis found with acute and chronic cholecystitis presumably had little or no clinical significance and did not appear to be an important element in causing clinical forms of cirrhosis.

Graham, in his studies, considered the presence of infiltrations of the portal fields with polymorphonuclear leukocytes and lymphocytes sufficient to make a diagnosis of hepatitis. Since this lesion is seen in a great variety of conditions, as Noble¹⁸ and others have certainly demonstrated, it is questionable whether this may be called a hepatitis. Some, notably Tietze and Winkler, in addition to these periportal infiltrations, have reported changes in the liver cells, and Albot,¹⁹ and Albot and Caroli²⁰ seemingly confirmed their findings by studies of the finer histology of the liver.

A further effort has again been made in this communication to study the question of the relationship of disease of the biliary tract to pathologic changes in the liver, with special emphasis upon the finer cytology of the liver.

Materials and Methods.—A special attempt was made to secure liver sections deep within the organ to obviate the current criticism that sections from the surface cannot be taken as an index of changes occurring throughout the liver. The gross pathology of the liver, gallbladder and bile ducts was carefully noted at operation. The gallbladder was aspirated of its fluid contents and a retrograde cholecystectomy performed when indicated. The excised gallbladder was then completely emptied, the cystic duct ligated and the organ was immediately distended with an amount of formalin equal in quantity to the aspirated bile. The distended gallbladder was immediately fixed in formalin. It was subsequently cut longitudinally so that a better idea might be gained as to the pathologic changes involving the entire organ. Sections were stained with hematoxylin and eosin, Weigert's elastica, and the iron-hematoxylin-van Gieson. Bacterial stains were performed on many of these sections.

Specimens of liver were taken either from the dome of the right or left

lobe, 2.5 to 3 cm. deep to the surface. The Hoffman biopsy punch was used routinely and was found excellent for this purpose, permitting the removal of pieces of liver tissue sufficient for study. Over 100 biopsies were performed and no untoward results could be traced to this procedure. If the liver bled profusely through the puncture, a plain or iodoform pack placed against the bleeding area and left in place for twenty-four hours controlled the hemorrhage and prevented any further complications.

The liver tissue was divided into three portions and fixed immediately in 10 per cent neutral formalin, absolute alcohol, and Regaud's solution. Hematoxylin and eosin, fat, glycogen, and Altmann's mitochondrial stains were performed routinely.

Histologic Findings.—The histology of the gallbladder was studied mainly in order to classify the degree of the inflammatory process present. This was done to determine whether any relationship existed between the acuteness of the cholecystitis and the changes observed in the sections of liver removed by biopsy.

The pathologic findings in the gallbladders were classified into two groups. Those in which a predominantly acute inflammatory process was present were placed in Group I, although many exhibited signs of a previous chronic inflammation, and stones. The second group, all of which were cases of cholelithiasis, consisted of those in which chronic inflammation dominated.

The histologic findings of the liver sections fell into two groups determined by the absence or presence of jaundice at the time of operation. These two groups were correlated with the previous classification of the gallbladder as follows:

GROUP I.—JAUNDICE ABSENT AT THE TIME OF OPERATION* (TABLE I)

- (a) Acute cholecystitis 11 cases 1
(b) Chronic cholecystitis 29 cases

* Cholecystectomy performed in thirty-seven cases, and cholecystostomy in three.

TABLE I

A.—Eleven Cases of Acute Cholecystitis without Jaundice Subjected to Biopsy of the Liver

Case No.	Operation	Previous History of Jaundice	Preoperative Icteric Index	Bilirubin Mgms. per 100 cc.
1	Cholecystectomy	None	7	0.2
2	Cholecystectomy	None	12	0.7
7	Cholecystectomy	None	14	0.6
34	Cholecystectomy	Slight	10	0.4
72	Cholecystectomy	None	—	—
74	Cholecystectomy	None	8	0.2
81	Cholecystectomy	None	17	0.2
82	Cholecystectomy	None	8	0.2
84	Cholecystectomy	None	6	—
18	Cholecystostomy	None	10	0.3
46	Cholecystostomy	None	6	0.2

TABLE I (Continued)

B.—Twenty-nine Cases of Chronic Cholecystitis without Jaundice Subjected to Biopsy of the Liver

Case No.	Operation	Previous History of Jaundice	Preoperative Icteric Index	Bilirubin Mgms. per 100 cc.
3	Cholecystectomy	None	—	0.2
5	Cholecystectomy	None	12	0.3
8	Cholecystectomy	None	12	0.3
10	Cholecystectomy	None	14	0.2
11	Cholecystectomy	None	12	0.2
13	Cholecystectomy	None	5	0.2
14	Cholecystectomy	None	13	0.3
16	Cholecystectomy	None	6	0.6
20	Cholecystectomy	None	15	1.5
22	Cholecystectomy	None	18	0.6
25	Cholecystectomy	None	26	0.2
33	Cholecystectomy	None	8	0.2
39	Cholecystectomy	None	14	1.0
40	Cholecystectomy	None	7	0.2
41	Cholecystectomy	None	28	3.5
44	Cholecystectomy	None	5	0.2
47	Cholecystectomy	None	17	1.1
48	Cholecystectomy	Repeated attacks	10	0.2
50	Cholecystectomy	None	8	0.2
54	Cholecystectomy	None	13	0.6
58	Cholecystectomy	Single attack	6	0.2
60	Cholecystectomy	None	12	0.3
63	Cholecystectomy	None	8	0.2
64	Cholecystectomy	None	10	—
70	Cholecystectomy	Single attack	9	0.2
73	Cholecystectomy	None	8	0.2
79	Cholecystectomy	None	7	0.3
83	Cholecystectomy	None	10	0.5
23	Cholecystostomy	Repeated attacks	15	0.5

GROUP II.—JAUNDICE PRESENT AT THE TIME OF OPERATION* (TABLE II)

- (a) Acute cholecystitis 6 cases
- (b) Chronic cholecystitis 3 cases

* Cholecystectomy performed in seven cases, and cholecystostomy in two.

TABLE II

A.—Six Cases of Acute Cholecystitis with Jaundice Subjected to Biopsy of the Liver

Case No.	Operation	Previous History of Jaundice	Preoperative Icteric Index	Bilirubin Mgms. per 100 cc.
24	Cholecystectomy	None	45	2.5
35	Cholecystectomy	None	45	3.0
42	Cholecystectomy	Transient	—	—
59	Cholecystectomy	None	40	0.5
28	Cholecystostomy	None	65	3.5
51	Cholecystostomy	Repeated attacks	48	3.5

TABLE II (Continued)

B.—Three Cases of Chronic Cholecystitis with Jaundice Subjected to Biopsy of the Liver

Case No.	Operation	Previous History of Jaundice	Preoperative Icteric Index	Bilirubin Mgms. per 100 cc
21	Cholecystectomy	Single attack	18	0.8
37	Cholecystectomy	None	25	1.2
49	Cholecystectomy	None	30	—

There were, in addition, two cases in which the gallbladder had been removed previously and secondary operation disclosed a complete stricture of the common bile duct in one, and incomplete obstruction by choledochal stone without jaundice in the other.

A group of cases were chosen to serve as controls. These comprised one of acute cholangitis with jaundice, seven presenting common duct obstruction with icterus due either to malignancy of the biliary tract, or of the head of the pancreas, and three in which there was no demonstrable disease of the gallbladder or liver.

In order to appreciate the findings present in the liver sections obtained by biopsy, it is necessary to point out certain histologic features of the normal liver. As a rule, a moderate number of lymphocytes and occasional polymorphonuclear leukocytes are found in the periportal connective tissue of the adult liver, more frequent in the smaller portal fields.^{21, 22} The presence of an increased number of round cells, together with an increase in the polymorphonuclear leukocytes and the presence of eosinophiles, can be considered pathologic.

The normal liver cells contain varying quantities of fat, dependent upon the state of nutrition of the liver cell. Brown pigment granules are often seen, and when present are found in the vicinity of the central vein.

In the normal liver lobule, small groups of cells with dark cytoplasm and small, deeply stained nuclei are often seen about the portal fields, less commonly about the central vein, and more rarely in small numbers in the middle zone of the lobule. These "dark" cells contrast sharply with the remaining liver cells, which are larger, possess a lighter staining cytoplasm, and a bigger, lighter staining nucleus with large nucleoli. The latter are termed "clear" or "light" cells. The significance of the "dark" cells has not been fully explained. Most investigators believe that they represent cells, either in a resting phase, or in a state of functional exhaustion.^{23, 24} The "clear" cells are considered to be physiologically active. The "dark" cells are devoid of glycogen, whereas the "clear" cells usually contain much glycogen and small fat droplets as well. Striking differences between the "dark" and "clear" cells are further evidenced by mitochondrial studies. In the "dark" cells, the mitochondria are closely packed or massed in the central portion of the cell, close about the nucleus, and do not appear along the cell membrane. Mitochondria are seen to be more or less evenly dispersed throughout the

"clear" cell, with distinct cytoplasmic spaces between groups or individual mitochondria. The distribution of the mitochondria in the "clear" cells depends to a great extent upon the amount of glycogen and fat present. If the cell contains much glycogen and fat, the mitochondria are pushed far apart and are unevenly dispersed throughout the cell. This dispersion imparts a very clear appearance to the cells, a condition which has been termed "clarification." These facts become more evident when a comparison is made between the glycogen, hematoxylin and eosin, and mitochondrial stains.

Some observers, particularly Albot in an interpretation of liver damage produced experimentally, have considered that both "clarification" and the presence of "dark" cells represent pathologic states. This has not been substantiated in these histologic studies.

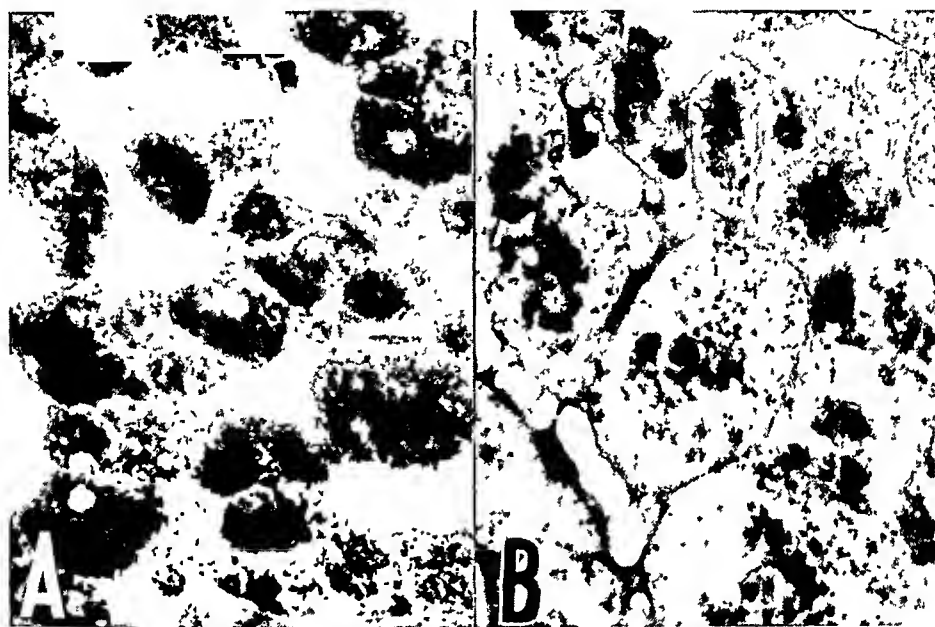


FIG. 1.—Liver of carrot-fed rabbit. (A) Best's carmine stain. All the cells are filled with glycogen. (B) Altmann's mitochondrial stain. Note the large, "clear" cells with dispersion of the mitochondria.

A series of experiments on rabbits was undertaken to study this particular problem. One group of rabbits was fed a diet of carrots for three days, another was starved for a similar period, and a third was kept on an average diet. The animals were then sacrificed, and sections of the liver were fixed at once and stained for glycogen, fat and mitochondria. It is well known that rabbits fed with carrots store an enormous amount of glycogen in the liver, whereas starvation will rapidly deplete the liver of glycogen. A study of the liver cells in the carrot-fed rabbits demonstrated that the presence of glycogen produces a marked enlargement of the cell, decided "clarification" and a dispersion of the mitochondria (Fig. 1). The liver cells of the starved rabbits were small, dark, devoid of glycogen and uniformly presented a massing of the mitochondria in the center of the cell (Fig. 2). Similar changes were noted by Hall and Mackay²⁵ in a study of the relation of mitochondria to glycogen in the rabbit liver cell. The conclusion may be drawn that the phenomenon of "clarification" or the presence of "dark" cells merely represents anatomic states dependent upon the physiologic activity of the cell.

The appearance of the mitochondria is of significance as an index of the physiologic or pathologic state of the liver cell, and is of great importance in the study of early parenchymal changes. Numerous investigators have established the fact that the earliest evidence of cell degeneration is to be found in alterations of the mitochondria.²⁶ These have been observed to change twenty-four hours before the nucleus disintegrates.²⁷ Pathologic alterations of the mitochondria are evidenced by a change in shape, with subsequent diminution in number, and disappearance by dissolution.^{27, 28} The shape of the mitochondria, which is normally either filamentous, or in the form of short, thick rods, or small granules, changes to a large globular form under abnormal conditions.²⁷ These globules are now seen as discrete bodies within the cell, in no particular relation to the nucleus. As the degeneration pro-

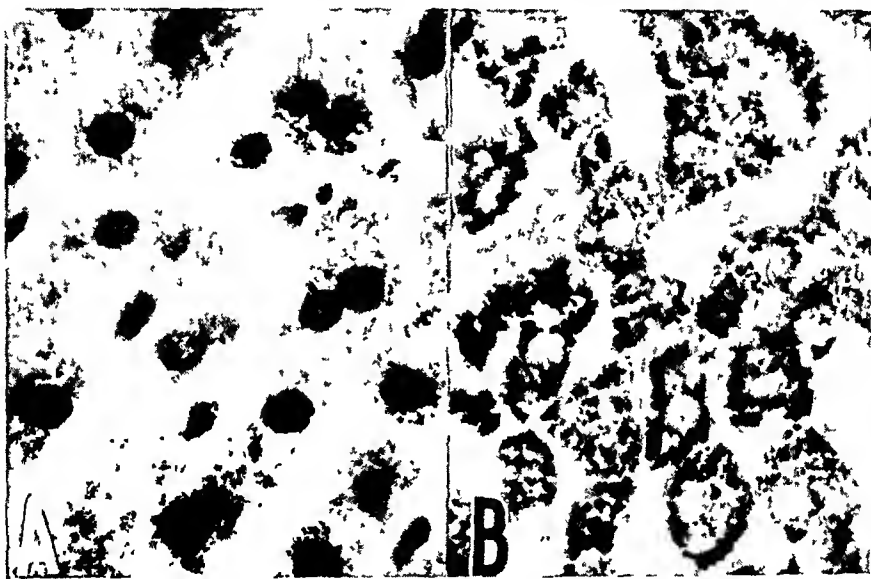


FIG. 2.—Liver of starved rabbit (A) Best's carmine stain. All the cells are devoid of glycogen. (B) Altmann's mitochondrial stain. Note the small, "dark" cells with compact massing of the mitochondria.

ceeds, the number of mitochondria in the cell is appreciably diminished, and ultimately the mitochondria completely disappear. Occasionally, mitochondria, although visible, lose their staining properties in the process of impending dissolution. It must be constantly borne in mind, however, that the mitochondria are affected by the various technical procedures involved in the preparation of sections.²⁸ Great care must, therefore, be exercised in ascribing pathologic significance to changes in shape and form.²⁸

The microscopic appearance of the liver with reference to its finer histology, especially the mitochondria, will now be detailed in the cases in this series.

GROUP I.—*No jaundice present at the time of operation.*—(a) Acute cholecystitis. There were eleven cases in this group. An infiltration of the periportal connective tissue with round cells was seen in nine, and in two of these the presence of an increased number of polymorphonuclear leukocytes was noted. No infiltration was observed in two cases. The inflammatory cells

were present in the connective tissue about the small vessels, bile ducts, and in the lymphatic spaces, but never within the wall or lumen of a bile duct. Polymorphonuclear leukocytes were only occasionally seen in increased numbers in the sinusoids. When present, they were usually observed in the capillaries about the portal fields. Fat was present in moderate amounts in seven instances, generally localized to the cells in the middle or central portions of the lobule. In many cases, the cells adjoining the central veins contained brown pigment. Glycogen was usually present in abundance. Areas of "clear" cells of varying extent, chiefly confined to the central and middle portions of the lobule, were seen to alternate with areas of "dark" cells. This was characteristic of all sections. The distribution of the mitochondria of the "clear" and "dark" areas was readily correlated with the presence or absence of glycogen. As in normal liver sections, glycogen-containing cells were large, clear, and showed the characteristic dispersion of the mitochondria, in contrast to the close packing of the mitochondria in the small, dark cells (Fig. 4 A). There were no pathologic alterations of the mitochondria.

(b) Chronic cholecystitis. There were twenty-nine cases in this group. A slight to marked infiltration of the periportal connective tissue by lymphocytes, plasma cells, and in some instances, polymorphonuclear leukocytes was noted in twenty. The lymphocytes and polymorphonuclear leukocytes were also seen in small quantities in the capillaries about the portal field in six instances. The distribution of the inflammatory cells within the periportal connective tissue was identical with that described in the cases of acute cholecystitis, essentially an infiltration about the small vessels, bile ducts and in the lymphatic spaces (Fig. 3 A). Infiltrations of the walls or lumina of the bile ducts were not noted. The periportal connective tissue was increased, with a widening of the portal field in several instances. Occasional bands of connective tissue were seen to extend for a short distance into the liver lobule from the widened portal field, sometimes surrounding small islands of unaltered cells (Fig. 3 A). Observations on the fat, pigment, glycogen and mitochondria of the cells (Fig. 4 B) were similar to those described in the cases of acute cholecystitis.

GROUP II.—*Jaundice present at the time of operation.*—These cases will be discussed together since they presented features which were identical in all respects. This group comprised six cases of acute cholecystitis, three of chronic cholecystitis, and one of common duct obstruction by choledochal stone occurring several months after cholecystectomy. Cholecystectomy was performed in seven cases and cholecystostomy in two.

A study of the liver sections unquestionably revealed a more marked infiltration of the periportal connective tissue by lymphocytes, plasma cells, occasional histiocytes, with polymorphonuclear leukocytes in abundance. Those cells often extended into the adjoining sinusoids. Occasional infiltration of the walls and lumina of the small bile ducts was observed in one instance (Fig. 3 B). The bile capillaries were dilated and filled by bile thrombi in

more than one-half of the cases. The extent of the bile capillary occlusion varied markedly. The liver cells in the immediate vicinity of these occluded bile capillaries often contained bile pigment granules and occasionally ex-

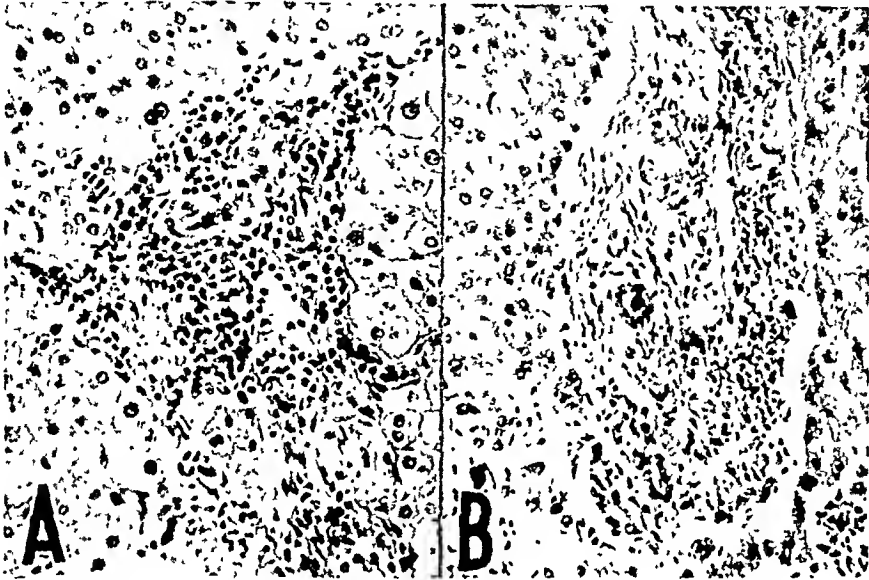


FIG. 3(A).—(Case LXX.) Chronic cholecystitis without jaundice. Infiltration of the periportal connective tissue with round cells and few polymorphonuclear leukocytes. There is some proliferation of the periportal connective tissue, which extends out into the lobule and isolates a small group of liver cells. (Hematoxylin and eosin.) (B) (Case LI.) Chronic cholecystitis with jaundice. Infiltration of the periportal connective tissue by inflammatory cells. There is some widening of the portal field. A small bile duct in the center contains several polymorphonuclear leukocytes. (Hematoxylin and eosin.)

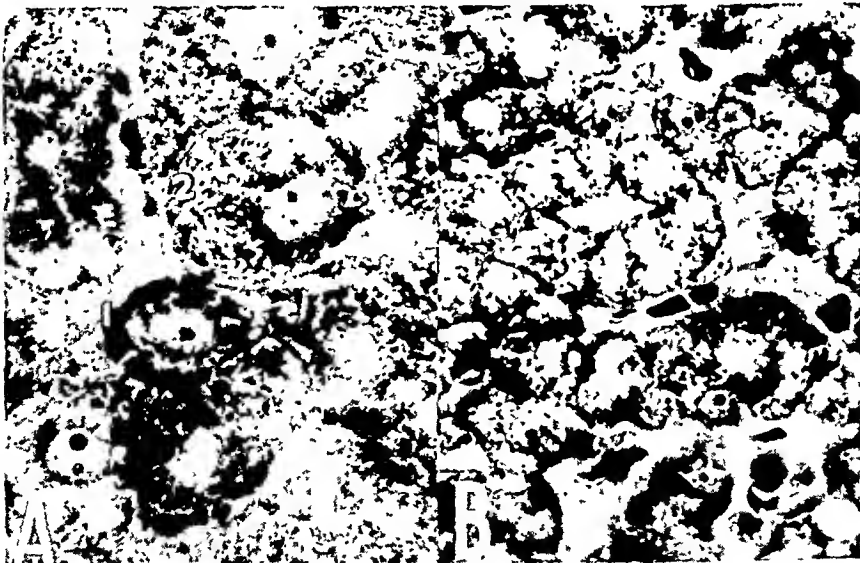


FIG. 4(A).—(Case XXXIV.) Acute cholecystitis without jaundice. Altmann's mitochondrial stain. Typical field showing "dark" (1) and "clear" (2) cells, with normal mitochondria. (B) (Case XXXIII.) Chronic cholecystitis without jaundice. Altmann's mitochondrial stain. Large area of "clear" cells with normal mitochondria.

hibited nuclear and cytoplasmic degeneration. These changes were more striking in areas exhibiting extensive and large bile capillary thrombi. Cell degeneration was not noted when capillary thrombi were not present. The

glycogen, fat and pigment content of the cells differed in no way from that observed in the nonjaundiced cases. While many cells containing bile pigment did not show the presence of glycogen, bile pigment and glycogen were often observed together in other cells.

The cases in which bile thrombi were minimal in extent or absent (about one-half of the group) presented no unusual changes in the mitochondria. Their appearance was identical with that seen in the nonjaundiced cases. However, striking alterations were present in the mitochondria of the cells in the immediate vicinity of extensive capillary bile thrombosis. These were manifested by the characteristic changes seen in mitochondriolysis (Fig. 5).

The mitochondrial stains served as a more reliable index of cell degeneration than hematoxylin and eosin. The mitochondria of cells distant to the areas of bile thrombosis were unaltered.

A comparison of the sections obtained from the livers in cases of cholecystitis with choledochal stones, and those obtained from cases of common duct obstruction due to ma-

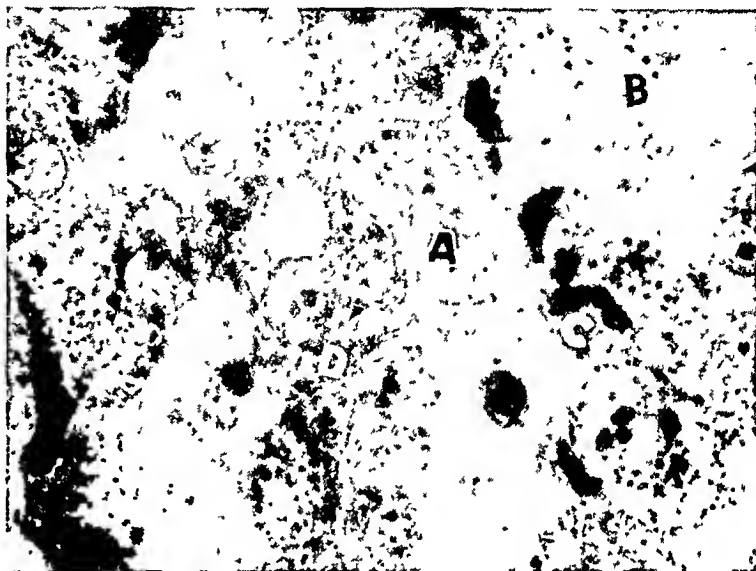


FIG. 5.—(Case XXVIII.) Acute cholecystitis with jaundice. Altmann's mitochondrial stain. Cells adjoining bile capillary thrombi (C) showing absence of mitochondria (A) and globular forms with diminution in number (B). Remaining cells (D) show normal mitochondria.

lignancy of the biliary tract or the head of the pancreas, in which long-standing jaundice was present, showed either identical or more pronounced mitochondriolysis. In the latter these alterations were seen likewise only in the areas of bile capillary thrombi.

The liver sections in one case of acute cholangitis showed infiltration of the walls and lumina of the bile ducts with polymorphonuclear leukocytes, desquamation of the epithelium of the bile ducts, in addition to infiltration of the portal fields. Foci of capillary bile thrombi were present throughout and cells in their vicinity showed the same striking mitochondriolysis.

Summary of the Histologic Findings.—Studies of sections of liver removed by biopsy in forty cases of acute and chronic cholecystitis, in which jaundice was not present at the time of operation generally presented infiltration of the portal fields by lymphocytes, occasional plasma cells, and polymorphonuclear leukocytes. This infiltration was limited to the periportal tissues and did not selectively involve either the perivascular or periductal regions, or the walls, or lumina of the bile ducts. A proliferation of the periportal connective tissue was occasionally noted. The fat, glycogen, and pigment

content of the liver cells was within normal limits. The mitochondria showed no deviations from the normal.

The liver sections from patients with jaundice presented the same periportal infiltrations, but usually more marked in extent. Proliferation of the periportal connective tissue was seen more frequently. The bile capillaries were dilated, and filled by bile thrombi in about one-half of the cases. Occasional liver cell degeneration, as evidenced by definite mitochondrial alterations, were observed about these capillary bile thrombi. The extent of mitochondriolysis was proportional to the severity of the bile capillary obstruction. Mitochondrial changes were not seen in the absence of bile capillary thrombi despite the clinical evidence of jaundice. The liver cells contained fat, glycogen and pigment, within normal limits.

Discussion.—Sections removed from the edge or surface of the liver are prone to present pathologic alterations which cannot be considered as representative of the organ as a whole. Metzler,²⁰ Enders,³⁰ and others have shown that with advancing age there is an atrophy of the liver edge, with an increase in the connective tissue of the portal fields in this area. Long-continued, mild external trauma, such as pressure from the rib margins and chronic inflammation in the upper quadrant of the abdomen with the formation of localized peritoneal adhesions, may be additional factors accounting for the scarring of the liver edge and surface. Certainly the liver tissues immediately adjacent to an infected gallbladder may show localized inflammatory reactions. It is, therefore, essential in order to properly evaluate the hepatic changes in diseases of the biliary tract to obtain sections from the deeper portions of the liver parenchyma at some distance from the gallbladder fossa. Sections in this study were taken deep to the dome of either the right or left hepatic lobes.

The majority of these investigations in the past has been limited to routine histologic studies. This method is frequently inadequate. A mere granular appearance of the cytoplasm cannot be taken as evidence of cell degeneration, unless this is confirmed by mitochondrial studies. Likewise, many have interpreted the presence of fat in the cells as evidence of fatty degeneration. Fat in the liver cell is a physiologic condition unless present in unusually large amounts. Misinterpretation may result in ascribing pathologic significance to varying physiologic appearances of the liver cell. The presence of small "dark" cells, or very large "clear" cells has been considered to represent a pathologic state. These appearances are physiologic, as this study and other investigations have shown.

A study of the liver parenchyma, with special emphasis on the finer cytology, showed no pathologic changes in all cases of cholecystitis without jaundice in this series. The hepatic changes in this type of case reported by many,^{4, 20} were not confirmed. However, in a series of cases with jaundice due to common duct obstruction by stone, in one case of acute cholangitis and in seven cases of obstructive jaundice, resulting from malignant tumors of the biliary tract or the head of the pancreas, the process of cell destruction could be verified by the alterations of the mitochondria. Mitochondriolysis, and to a lesser de-

gree concomitant nuclear and cytoplasmic changes, were observed only in the vicinity of bile capillary thrombi. This destruction was due to changes incident to obstruction. It bore no relationship to the changes occurring in the gallbladder. The extensive necrosis of liver cells reported by some observers⁴ was not confirmed in this study.

Nearly all the investigators have stressed the presence of periportal cellular infiltration in biliary tract disease. This infiltration of inflammatory cells was present in varying degrees in all the cases considered in this study, more marked, however, in those instances in which jaundice was present at the time of operation. Periportal connective tissue proliferation was observed in a number of instances of chronic cholecystitis. These patients, not infrequently, gave a history of previous attacks of icterus.

Periportal cellular infiltrations have been interpreted as evidence of cholangitis and pericholangitis. A diagnosis of cholangitis cannot be made unless there is a cellular infiltration of the walls or lumina of the bile ducts, with consequent widening, desquamation of the epithelium and the presence of an intraductal exudate. However, many have ventured a diagnosis of cholangitis, in spite of the fact that these criteria were not satisfied by their protocols. It is incorrect to state that a pericholangitis exists unless the presence of a cholangitis is assured. A diagnosis of pericholangitis based only upon the presence of cells about a bile duct, as seen in the normal course of a periportal infiltration, is not justified. Furthermore, a periportal infiltration associated with periductal orientation of cells is observed in many other conditions in which the disease of the biliary tract can be excluded definitely by detailed postmortem studies.

Kahlstorf²² examined the liver in 207 necropsies and found periportal infiltrations in disease of the biliary tract, chronic and acute disease of the gastro-intestinal tract, and in 92 per cent of general infections. He concluded that periportal infiltrations are inflammatory in nature, analogous to other inflammatory conditions inasmuch as polymorphonuclear leukocytes were noted in acute processes, and lymphocytes, plasma cells and histocytes in the chronic processes. Kettler,²¹ in a similar study, concurred in this view and stressed especially the presence in general infections of these infiltrations which may remain long after the initial disease had subsided. While he believed these inflammatory reactions could lead to a slight scarring of Glisson's capsule, they never produced a cirrhosis, and were without clinical significance. Noble likewise studied the liver in 212 routine necropsies and found periportal infiltration in all but two instances. He gave no explanation for the constant presence of these cells, but believed that they were unrelated either to general infections or to any specific type of disease. Noble found that nonclinical cholecystitis was frequently accompanied by periportal infiltrations and agreed with Martin¹⁷ that the inflammation, *i.e.*, the presence of periportal cells, could be secondary to the presence of bacteria and toxic substances carried to the liver by the portal blood.

Periportal infiltrations, obviously, are not a reaction of the liver specific for biliary tract disease.

The proliferation of the periportal connective tissue in instances of long-standing biliary tract disease can be explained both by periportal irritation and by bile stasis in cases with obstructive jaundice.

Jaundice, although latent, with an icteric index of 16 to 18, may not be evident clinically in incomplete obstruction of the common duct. If, then, this condition of latent jaundice exists over prolonged periods of time, focal liver cell degeneration will result in areas of bile capillary thrombosis and proliferation of the periportal connective tissue will ensue. This is essentially what happens in cases of chronic cholecystitis in which previous attacks of jaundice were present, or in which the icterus has been latent. This histologic picture has been interpreted as indicative of early biliary cirrhosis. Such an interpretation is not justified since the proliferation of the periportal connective tissue is only focal in character.

The use of the term "hepatitis," without qualification, is incorrect when applied to those cases of biliary tract disease without jaundice in which only periportal infiltrations without any liver cell changes are present. Even the additional presence of focal liver cell damage, in cases of cholecystitis with jaundice, is not indicative of hepatitis. Hepatitis is a primary disease of the liver characterized by an inflammatory process in the framework associated with diffuse parenchymal changes. This was not found in biliary tract disease.

The use of the term "interstitial hepatitis" may be justified from the mere morphologic point of view. However, inasmuch as periportal infiltrations are very frequently indicative of a reaction to extrahepatic infection and do not represent a primary inflammation of the liver, the diagnosis of "interstitial hepatitis" loses its significance in these instances.

The designation "focal hepatosis" may be used in obstructive jaundice with focal cell degeneration. It is unlikely that transient attacks of obstructive jaundice will lead to serious parenchymal alterations. Obstructive jaundice over prolonged periods, however, results in both advanced parenchymal and interstitial alterations, representing true biliary cirrhosis.

CONCLUSIONS

Biopsy of the liver was performed in 40 cases of acute and chronic cholecystitis without jaundice, and in nine with jaundice. Studies with finer histologic technic revealed no changes in the liver cells in biliary tract disease without jaundice. Focal liver cell degeneration seen in cases with jaundice represents a reaction to bile stasis and is in no way related to the primary disease of the gallbladder. The periportal infiltrations observed in biliary tract disease are not specific for the disease, but represent a reaction of the liver to extrahepatic infection. Hepatitis is not an accompaniment of cholecystitis as evidenced by the absence of inflammatory and parenchymal changes in the liver.

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DISCUSSION.—DR. WALTON MARTIN (New York) pointed out that Doctor Colp, by taking sections of the liver distant from the bed of the gallbladder, had demonstrated that the liver parenchyma shows no evidence of pathologic change, studied with special emphasis on the finer cytology, in cholecystitis without jaundice. He said further that at the time Doctor Graham presented his views regarding the interrelation of hepatitis and cholecystitis his arguments seemed unconvincing insofar as they did not take sufficiently into account the distinction between hepatitis contiguous to the inflamed gallbladder and which would be expected about any focus of infection and generalized hepatitis; secondly that he placed no stress on the well-recognized observation that disturbance of the liver cells inevitably follows the slightest infection or blocking of the excretory duct of the liver following a law that is common to all glandular structures—the kidney, the pancreas, the mammary and salivary glands, *et cetera*, and that he failed to recognize the frequency of the reaction of the liver cells to all manner of toxic agents brought to it by the blood stream.

Moreover, Graham's views do not seem to be in accord with common clinical experience such as the prompt return to vigorous health after the removal of a severely infected gallbladder even with a history extending over years, provided that there has been no involvement of the common duct, the follow up on these cases showing neither cirrhosis nor hepatitis. Further severe infections of the liver such as are seen with pyogenic infection of the portal vein are not accompanied by corresponding cholecystitis and autopsies on acute hepatitis do not show gross lesions of the gallbladder; neither do the specific infections such as tuberculosis or syphilis set up as a rule specific cholecystitis. Tuberculosis of the gallbladder is extremely rare, although small tuberculous lesions are nearly always present in the liver of tuberculous patients if careful search is made according to Calmette.

DR. CHARLES GORDON HEYD (New York) said that any discussion of changes in the liver, incident or sequential to abdominal infection, should be prefaced by a consideration of Adami's paper on "Subinfection" and the studies of Mallory on "Toxic Lesions of the Hepatic Cells." It is widely held, Doctor Heyd thought, that the liver and spleen, separately or jointly, act as sieves to strain out bacteria. The performance of an Eck's fistula demonstrates that all of the subjects died in six to eight weeks of a general septicemia. Without the interposition of the liver between the portal system and the general circulation, few people could survive as septicemia would be the rule. When considering changes in the liver, it is important to remember that one of the vital functions of the liver is regeneration. An individual maintains relatively good liver functional capacity if and when the regenera-

tive process is equal to any simultaneous degenerative process. Furthermore, in the microscopic lesions in the liver one must approach the study from two points of view: Is the primary liver injury in the course of the biliary system, or is the primary liver damage through the central vein of the portal vascular system?

Doctor Heyd felt that it was unfortunate that Doctor Colp had introduced the changes in the liver cells in patients with obstructive jaundice as pertinent to his study. The pathologic changes in the liver in the presence of obstructive jaundice are obviously gross, for within a very short time after the initiation of an obstructive jaundice there is a progressive degeneration of liver cells and the liver, either locally or somewhat generally, is the site of an intense chemical and possibly infective irritation and the result is a tremendous edema of the liver. At operation, one is profoundly impressed by the gross appearance of the liver in the presence of a long-continued jaundice, as brought before the New York Surgical Society by Doctor Heyd in April, 1926, and again in January, 1928.

The greatest degree of liver enlargement in obstructive jaundice is due to the serum edema and if these livers are removed at autopsy and suspended in toto as much as 500 to 100 cc. of serum can be obtained by drainage.

There are certain types of liver injury that do occur in infection of the gallbladder and bile ducts without jaundice. In one of Doctor Heyd's cases, from a portion of liver removed at operation it was possible to trace sequential pathologic stages from the gallbladder up to polynuclear cells on or about the smallest collecting bile canaliculi. When one discusses the changes that occur either primarily in the liver by means of the portal system or secondarily from gallbladder infection, Doctor Heyd believed some of the pathologic inferences of Doctor Colp and his associates are, in a measure, justified. To be sure, the authors were handicapped by the small size of their biopsy specimens, and their studies of the liver cell for mitochondriacal bodies are certainly of value in indicating degenerative changes in the individual cells within the hepatic columns. It is not proper, however, to regard such changes in the individual cells as evidence of inflammation. The work presented by Doctor Colp deals very definitely with changes in the liver cells due to obstruction and intoxication, but has relatively little relationship to actual hepatitis in which the framework of the liver shows markedly definite changes.

DR. ALLEN O. WHIPPLE (New York) mentioned the fact that an adequate study of portal blood bacteriology, both aerobic and anaerobic, has not as yet been made in human cases. Such a study, he said, would give valuable evidence in regard to the problem of periportal infiltration and the ability of the liver to take care of bacterial invasion. It was stressed by Doctor Colp and emphasized by Doctor Martin that the tissues examined in Doctor Colp's series were not in the immediate neighborhood of the gallbladder. In the past, certainly, tissues removed for examination have been those most easily removed from the edge of the right lobe of the liver in the neighborhood of the gallbladder. These should not be taken as criteria of the liver pathology as a whole.

THE SEQUELAE AFTER CHOLECYSTOSTOMY

WITH SPECIAL REFERENCE TO CHOLELITHIASIS

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THIS paper represents a study of 500 cases of gallbladder disease from 1921 to 1932. In this series there were 125 cholecystostomies, 151 cholecystectomies, and 224 cases upon whom no operation had been performed. The mortality of the first group was 16 per cent, of the second 2 per cent, and of the third 1.3 per cent. No attempt is being made to present a complete résumé of the drainage cases but rather to indicate features that have been of special concern to our observers in the Follow-up Clinic of the Third Surgical Division of the Bellevue Hospital.

Of these 125 cholecystostomies follow-up data were obtained in 87. Five individuals subsequently underwent cholecystectomy for stones after an average duration of ten years. Four submitted to removal of the gallbladder for biliary fistula after a mean period of two years. Twenty-two of these return patients complained of pain in the operative scars or within the abdomen and not directly attributable to the gallbladder. In this latter category belonged two with syphilis, three with carcinoma, two upon whom gastro-enterostomy had been performed, and seven with herniae. Thirty-nine patients have apparently remained entirely symptom-free or 46 per cent of the 87 who returned after drainage of the gallbladder.

It is noteworthy that but two of these individuals gave evidence of diabetes and continued under treatment at the Diabetic Clinic, although it is known that the typical patient with calculus cholecystitis presents a hyperglycemia with or without glycosuria before operation. Harrison has constructed a summation curve for the "gallbladder" and one for the "non-gallbladder" patient and finds that this diminished sugar tolerance in the gallbladder case corresponds remarkably with that of the blood sugar of the experimental series previously reported.^{1, 2, 3} Furthermore, it is gratifying that definite progress in the apparent arrest of pancreatitis followed drainage of the bladder especially in a group of cases recognized to be the most acutely ill of all the gallbladder series. Conversely, it is interesting to compare Joslin's⁴ observation that 15 per cent of 400 of his diabetics two years previously had been diagnosed as cholelithiasis. He advised cleaning up the bladder infection; and cholecystostomy appears to have aborted "pre-diabetics" in this series.

The incidence of approximately eight per cent seems high for post-operative herniae. Many factors appear to enter into this incisional rupture. The patients were obese manual workers of the clinic type. They were

difficult to protect against wound strain because even among those for whom proper abdominal supports had been obtained there were those who admitted wearing the corsets only when they dressed up to go out while they saved them and put on any old and probably worthless supports to do the scrubbing and washing. Nor would they properly attend to their diets. They continued to increase in weight after operation notwithstanding most of these people were already too obese when first observed. The use of two drains at the upper angle of the cholecystostomy wound is not believed *per se* to substantially increase herniation over that of the cholecystectomy wound with one drain. But the drainage is greater and more prolonged in the cholecystostomy patient, and the discharge may and often does contain digestive ferments through reflux of duodenal secretion through an incompetent bilioduodenal sphincter and the common bile duct. This discharge too often finds its way through the fat layer of the wound to the lower angle most often during the second postoperative week. When the patient is elevated on a backrest this makes counterdrainage necessary, and delays the healing of the wound. Therefore prolonged irritating discharges from the bladder should probably be considered an important causative factor along with overweight, faulty diet, overstrain, and the mechanical presence of the two drains in the production of incisional hernia following cholecystostomy.

Herniation of the wound is a complication of the operation, but fistula and stone recurrence indicate unresolved cholecystitis with or without cholangitis. This latter condition, amounting to 21 per cent of the return drainage cases, detracts from the operation of cholecystostomy as a permanent means of treating cholelithiasis.

Biliary fistula occurred in 11 per cent of the postoperatives of this series. This complication is not to be regarded as unfavorable in that these particular individuals occasionally developed chills and fever if the fistulae were tem-

TABLE I
Showing Effect upon Human Gallstone Left in Normal Canine Gallbladder

Exp. No.	Dura- tion in days	Color	Wt. gr. before	Shape	Color	Wt. gr. after	Shape	Net loss gr.
25	20	White	2.0	Facetted	Brown	1	Ovoid	1.0
26	26	White	31.0	Mulberry	0	0	0	31.0
36	25	Yellow	15.5	Mulberry	0	0	0	15.5
45	126	White	9.28	5 facets	0	0	0	9.28
50	60	Brown	18.5	Ellips'l	Brown	8.5	Ellips'l	10.0
57	77	Green	2.75	3 facets	0	0	0	2.75
		Green	6.5	4 facets	0	0	0	6.5
81	84	Brown	18.5	Mushroom	Brown	16	Mushroom	2.5
90	63	Green	7.38	7 facets	0	0	0	7.38

Roentgenograms of all bladders after tetrachlorphenphthalcin excepting Nos. 45 and 50 were negative for stones.

porarily closed. Chronically diseased functionless bladders kept up inflammation and required drainage of the exudate or allowed stones to reform. In two of these patients with fistulae epitheliomata developed about the external openings. Reoperation and cholecystectomy were successful in the four cases of this group who consented to rehospitization.

The chief interest in this report has been the recurrence of stones. Five of the cases reoperated upon were found to have stones; but there were three additional with positive cholecystograms, and one clinically diagnosed cholelithiasis. These nine indicate an approximate ten per cent recurrence after cholecystostomy.

The etiology of stone formation in gallbladders has been under investigation. It was long thought to be associated in some way with biliary stasis. Recently conditions under which concretions take place have been more definitely stated.

It is generally understood that gallstones are the product of abnormal conditions within the biliary tract and that stones disappear if exposed to normal bile within a normal bladder. Phemister, Day, and Hastings⁵ in a series of animal experiments supplementing observations upon 48 human cases of cholelithiasis concluded that "obstruction to the outlet of the gallbladder at least of a high degree and a low grade chronic inflammation are essential for the formation of separate deposits of calcium carbonate in the gallbladder." They further state that calcium is derived from the wall of the bladder and when thrown down in sufficient amount precipitates. Andrews,

TABLE II

Showing Effect upon Human Gallstone of Ligation of Cystic Duct

Exp. No.	Duration in days	Condition of bladder (after)	Glands	Pancreas	Stone wt., gr.	
					before	after
90B	3	Thickened			5.75	6.50
91	5	Ac. inflam.			7.0	7.125
94	17	Thickened	Enlarged		1.0	0
101	31	Ac. inflam.		Thick	6.0	7.25
102	31	Ac. inflam.	Enlarged	Thick	7.125	9.0

Dostal, Goff, and Hrdina⁶ conclude that cholesterin stones "result from the absorption of bile salts by the diseased gallbladder with consequent precipitation of cholesterol."

In the authors' experiments reported in 1928⁷ (Tables I and II) the obstruction of the cystic duct and foreign body cholecystitis were shown to be the essential etiologic factors in stone formation. The canine bladder deposited calcium carbonate about the human calculus (which was used as the foreign body in these experiments) in amounts apparently varying directly within the limits of the experiments with the length of exposure within the bladder. No attempt was made to produce a bacterial cholecystitis through the introduction

SEQUELAE AFTER CHOLECYSTOSTOMY

of bacteria for the surgical traumata and foreign body irritation inevitably set up inflammatory changes within the gallbladder wall. One should not

Before 15½ gr. After: No Stone Found.

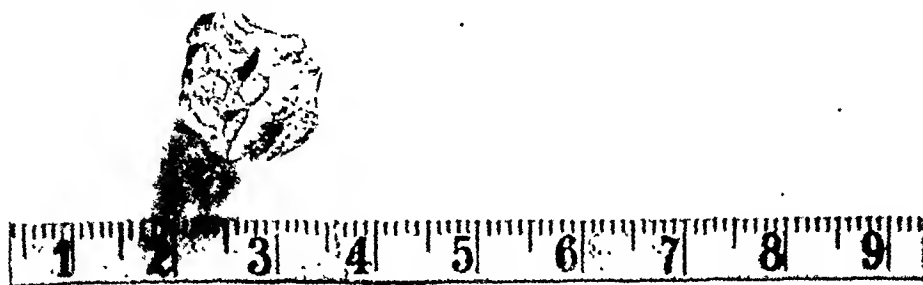


FIG. 1.—(See Table I.) Human calculus upon insertion in canine gallbladder. Disappeared in twenty-five days.

expect one of these bladders that has excreted calcium or has been exposed to irritation from stones to again become absolutely normal, nor should one

Before 9.28 gr. After: No Stone Found.

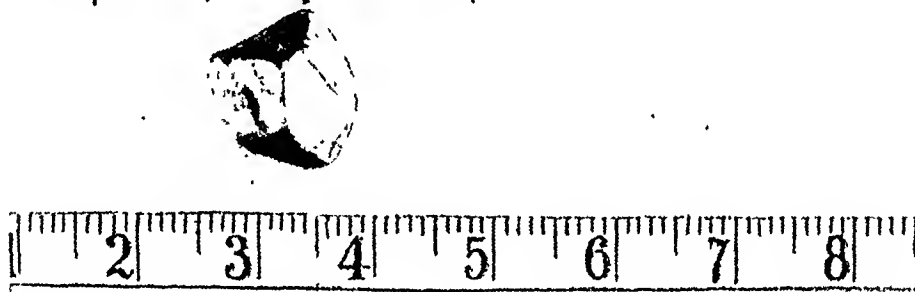


FIG. 2.—(See Table I.) Human calculus upon insertion in canine gallbladder. Disappeared in 126 days.

expect a potential stoneforming bladder to change into a bladder in which stones are absorbed. Repeated reoperations disclose stones previously observed but very rarely if ever absent from the gallbladders.

Before 18½ gr. After 8½ gr.



FIG. 3.—(See Table I.) Human calculus upon insertion in canine gallbladder. Decreased in sixty days.

This organic change in the bladder wall may not interfere with natural emptying under the roentgen ray. The active circulation of normal bile is

thought to be of greater value in preventing the reformation of concretions than a healthy bladder wall (Table III). To determine how much influence a badly damaged mucosa has on stone production the mucosae of four canine bladders were curetted, after which the bladders were sutured about human stones as in Table I. Note that in three out of the four animals the stones disappeared. In the single exceptional case (Table III), in which increase in weight of the calculus was observed after curettement of the lining of the bladder, the organ was atrophic and probably functionless.

TABLE III

Showing Effect of Curettement of Bladder Mucosa upon Human Gallstone

Exp. No.	Duration in days	Condition of bladder	Glands	Stone wt. gr.	
				before	after
93	7	Thickened	Enlarged	5.75	5.0
95	41	Normal (?)		7.875	0
A	31	Atrophic		6.0	7.5
100	31			7.125	4.125

Cf. loss in weight of bladder stone in Table I and Table III, indicating curettement of mucosa as possible negligible factor and circulation of bile as probable essential factor in the disintegration of a biliary calculus.

In the clinical cases above reviewed all the gallbladders had once been acutely inflamed, practically all had contained stones, many had become functionless as determined by the roentgen ray and failed normally to discharge bile. Recurrent cholecystitis and obstruction to the natural flow of bile (above reproduced in the experimental animals) statistically accounted for ten per cent of the 87 return "cholecystostomy" patients who subsequently developed new stones. Fistula formation probably prevented a higher incidence of recurrence by decompressing the inflamed bladders.

SUMMARY

(1) Of 500 gallbladder cases, 125 had cholecystostomy with 16 per cent mortality, 151 had cholecystectomy with two per cent deaths, and 224 had no operation with a fatality of 1.3 per cent.

(2) Of these 125 ostomies (1921-1932) 87 returned for follow-up examination. Of these 46 per cent remained symptom free. Of the remainder, 25 per cent complained of pain not attributable to the gallbladder. Hernia was observed in eight per cent. Fistula occurred in 11 per cent. Ten per cent developed recurrent stones.

(3) The improvement in the sugar tolerance was believed to vary directly with the subsidence of the biliary infection.

(4) Stones were found to disappear in normal canine gallbladders but to increase in size in the presence of obstruction and inflammation. The integrity of the mucous lining appeared to be a negligible factor in the disappearance of calculi.

(5) The recurrence of cholecystitis with impairment of the outflow of bile from the gallbladder were considered to be the essential causative factors of stone formation.

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HISTOLOGIC GRADING OF MAMMARY CARCINOMA

IN A SERIES FOLLOWED FOR TEN YEARS

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THE attempt to establish the prognostic significance of variations in tumor morphology seen under the microscope was first made by von Hanseemann.¹ It was soon found that separate categories were necessary in classifying tumors of different organs. In the study of mammary carcinoma, the work of Greenough² revealed a parallelism between histologic evidences of tumor anaplasia and growth activity on the one hand and clinical results as estimated by the rate of cures at the end of five years' observation, on the other. White,³ in his series of 100 cases, obtained results confirming the relationship found by Greenough.

However, many attempts to establish a definite prognosis in individual cases, from the histologic findings themselves, have proved unsuccessful. The reason for this nonsuccess rests on inability to determine by any means of clinical or operative examination the true extent of the disease in each case. Beyond doubt, most of those cases in which axillary metastases are found at operation or in the operative specimen have deposits of tumor cells in other nodes or in distant organs. Since such cases do not allow of surgical extirpation of the disease, their inclusion in a series of cases operated upon leads to confusion, and this confusion of cases pursuing their natural life histories and cases cured or helped by operation is probably the dominant, although accidental, element, which makes one series of cases different from another in which the same operative procedures were employed. The only group in which any uniformity of disease extent is probable is that of carcinoma in which careful search of the axillary nodes reveals no metastases. This group becomes relatively smaller after operation than before, and still smaller if the pathologic examination is painstaking and done by one familiar with the anatomy of the nodes of this region.

The original pathologic classifications of carcinoma of the breast distinguished medullary, adenocarcinoma and fibrosing (scirrhous) types. Classified on such a basis, it was found by Salomon⁴ that adenocarcinoma was the most favorable group. Lindenberg⁵ and later Boss⁶ were unable to make this distinction and the latter found scirrhous carcinoma to have the best prognosis of the various categories. On the other hand, the unfavorable nature of scirrhous carcinoma appeared indicated by the analysis of 126 cases by Feist and Bauer.⁷

In Greenough's groupings, the original criteria of von Hanseemann were used, rather than mere subdivisions based on cell patterns and fibrous tissue

content. He placed emphasis on those morphologic features connected with cellular differentiation and function, namely, grouping in acinus formation and content of secretion. Such cells were well differentiated and therefore to be considered of lesser malignancy. Other factors considered by Greenough were regularity in size of cells and nuclei and in the chromatin arrangement in the nuclei, and the frequency of mitotic figures.

Instead of the above criteria, MacCarty⁸ believed greater importance was attached to the degrees of fibrosis, hyalinization and lymphocytic infiltration as factors tending toward encapsulation and possibly defensive reaction, comparable to that seen in tuberculosis.

Heuper⁹ combined all these histologic factors and added to them such minutiae as the nucleocytoplasmic ratio, the vascularity of the stroma, and the number of "pencil" cells, considering in all 20 separate features as having some weight in the prognosis.

Recent surveys of case groups have tended to throw doubt on the significance or value of many of the factors previously considered important. Evans¹⁰ found that fibrosis and lymphocytosis could not be made to show any correlation with eventual outcome in his series. He could likewise find no significance in a casual estimate of the frequency of mitotic figures. He could find some significant correlation with prognosis only in regard to two factors, tubule formation and cell regularity of shape and size. The cases with uniform cells with definite tubular arrangement were obviously more favorable in outcome.

Haagensen¹¹ studied exceptionally favorable material in a series of 164 cases and found that, analyzed for each one of 15 histologic details, the ones which bore no statistically convincing relationship to outcome were: (1) Hyperchromatism of nuclei; (2) fibrosis; (3) hyaline degeneration; (4) lymphocytic infiltration; (5) plexiform arrangement. The factors having significant variation in favorable and unfavorable cases, he found were: (1) Papillary arrangement; (2) comedo formation; (3) adenoid arrangement; (4) variation size and shape of nuclei; (5) number of mitotic figures; (6) gelatinous degeneration.

STATISTICS OF THIS SERIES

This study was made on a series of cases of carcinoma of the breast in which operative radical removal of the breast had been performed by the Halsted method or a modification of it and a postoperative record was available. The cases were obtained from those operated upon at Roosevelt Hospital between 1915 and 1925 and therefore a postoperative history of from ten to 21 years was available. These records had been assiduously maintained by Dr. William Crawford White, without whose assistance the study would have been impossible.

There were 124 cases falling into the period and having both sufficient postoperative data and tissue slides for microscopic grading. Of these cases the age at time of operation ranged from 29 to 77 years. Seventeen cases of

women of 40 years or less appear in the series. Four of these (24 per cent) were well and free of disease for periods of from 10 to 21 years after operations. One case died 12½ years postoperatively of unknown cause, and another six years postoperatively of recurrence. The total group showed 18 or 14 per cent, cured after this prolonged period of follow up. There remain also a group of eight in whom no clinical evidence of tumor was present at the time of death six to 14 years postoperatively. If these are added to the cured cases, the percentage of cure is 20 per cent.

The method of study employed in this analysis was as follows: The available microscopic slides were examined as a group, without reference to information as to the clinical outcome. A separate grade from one to three was ascribed to each of those factors in histologic structure to which credit for influencing rapidity of tumor growth has been assigned by various authors. These were nuclear size, nuclear constancy or variability of size and form, regularity of adenoid cellular grouping, number of mitotic figures, presence of papillary structure, number of lymphocytes infiltrating the tumor, extent and density of fibrosis, amount of intracellular secretion and occurrence of comedo formation.

The cell sizes were not considered reliable because of difficulties due to thick sections and variable dehydration. The nuclei were therefore used as a better criterion. A representative group of nuclei was traced by camera lucida from each slide. These drawings were then used to assign each case a grade as to nuclear size and another as to nuclear variability. The numbers used throughout were in ascending scale of probable malignancy, and therefore the small and uniform nuclei were graded one and the large and irregular ones three. The use of camera lucida drawings was thought to furnish a check on personal variations in opinion. Where the cells varied from section to section, the practice was to use the looser portions or the cells invading fat, rather than those buried in dense fibrous stroma. After all the slides had furnished representative groups of nuclei, a decision was reached as to which belonged to the smallest and which to the medium and largest groups. Likewise, since 8 to 15 nuclei had been drawn for each slide, it was possible to decide on the relative constancy or irregularity of nuclei, using the other drawings as a check on each decision.

The content of secretion was not estimated by special staining, since the original tissue had all been fixed in formalin. There is still considerable question whether the mucicarmine stain is as valuable as claimed by Delbet.¹² Besides the absence of a series of cases in which it has been done and the relation to outcome compared with the relative degrees of secretion observed, theoretically alone it is discouraging to realize that glycogen frequently stains with mucicarmine and has caused considerable confusion thereby in the study of the glandular epithelium of the endometrium. In this study the presence of vacuoles of secretion, of intracellular and intratubular hematoxylin staining material and of clarity of cytoplasm were noted as significant of varying degrees of secretion.

Mitotic figures were estimated by counting the number in ten high-power (x400) fields in different parts of the slide. If many fields showed none, the case was grouped as one. If each field showed several, the grouping was three.

The arrangement in glandular tubules was expressed as greatest (1) when the predominant mass of the tumor had cells grouped about a lumen, and as medium (2) when such arrangement was seen in some foci while many solid nests and narrow strands were also seen. When only the latter form of growth was found, the classification was Grade III.

The intensity of fibrosis and of lymphocytic infiltration was graded from one to three, giving the greatest degree of each the value one, according to the idea that they were defensive factors.

After this scheme had been completely fulfilled, the case histories were filled in opposite each case number, giving the years of survival and data as to recurrence or metastases. It was now possible to tabulate the cases in groups, three grades for each of the following factors: nuclear size, nuclear variability, mitosis, degree of lymphocytic infiltration and degree of fibrosis. Only two grades were found practicable in regard to adenoid arrangement, since there were so few cases with Grade I tubule formation, and likewise only two groups for secretion were finally achieved. Papillary structure and comedo arrangement did not occur often enough (five cases in all) to furnish separate groups. These factors were, however, weighed in the combined grading discussed below.

Table I represents the total group, showing how the occurrence of axillary metastases varied with the grades of the several histologic criteria. The striking positive feature is the definite preponderance of axillary metastases in the group graded three compared with that graded one and two as to adenoid arrangement. It would seem that the tumor with well formed tubules is more favorable on account of its slowness to metastasize and the frequency with which at operation no axillary metastases are to be found. All other criteria fail to show such a definite correlation with the percentage of metastatic involvement.

TABLE I

Percentage of Axillary Metastases Found in Pathologic Examination of 124 Cases, Graded by Separate Criteria

	Grade I	Grade II	Grade III
Nuclear size.....	65%	64%	75%
Nuclear variability.....	59%	70%	77%
Adenoid arrangement.....	49%		80%
Secretion.....	62%		71%
Mitosis.....	64%	73%	73%
Fibrosis.....	74%	74%	60%
Lymphocytes.....	63%	71%	73%

The entire group revealed an incidence of positive axillary nodes in 69 per cent of cases. It is evident from the Table that grading by each of the criteria employed reveals an increased incidence of axillary metastases in the higher grades, except in the grading according to fibrosis. The greatest variation and positive coincidence of grading and metastases are found in the subdivisions on the bases of adenoid arrangement. The next greatest are noted in the grading by variability of nuclei. All other criteria, except degree of fibrosis, show some positive coincidence but not of such marked degree.

The second method of analysis was a comparison of groups graded by the same criteria restricted to cases in which no axillary metastases were found by pathologic examination. The clinical outcome in such cases should be dependent upon the growth activity of the tumor itself, rather than upon unknown extensions of the disease as is the case with those having axillary metastases. Table II reveals the results of such an analysis. The great weakness is the paucity of the material. A substantially longer life and a greater percentage of ten year cures are found in the cases graded one as to nuclear variability, nuclear size, secretion, lymphocytic infiltration and mitoses. Grade II was found intermediate between one and three except in the case of lymphocytic infiltration to grading by degree of fibrosis, the Grade I appeared paradoxically unfavorable.

TABLE II

*Thirty-nine Cases Without Axillary Metastases Graded by Separate Criteria
Showing the Years of Survival of the Dead and the Percentage of Living Cases after Ten Years*

	Grade I	Grade II	Grade III
Nuclear size.....	4.4 yrs.—64% living	3 yrs.—53% living	3.2 yrs.—39% living
Nuclear variability..	5.2 yrs.—73% living	3 yrs.—45% living	2 yrs.—37% living
Adenoid.....	4 yrs.	52% living	2.5 yrs.—50% living
Mitosis.....	3.9 yrs.—50% living	1.5 yrs.—73% living	3.2 yrs.—17% living
Secretion.....	5.7 yrs.	56% living	2.3 yrs.—48% living
Lymphocytes.....	4 yrs.—73% living	3.3 yrs.—31% living	3.3 yrs.—46% living
Fibrosis.....	2.1 yrs.—33% living	3.4 yrs.—53% living	4.1 yrs.—50% living

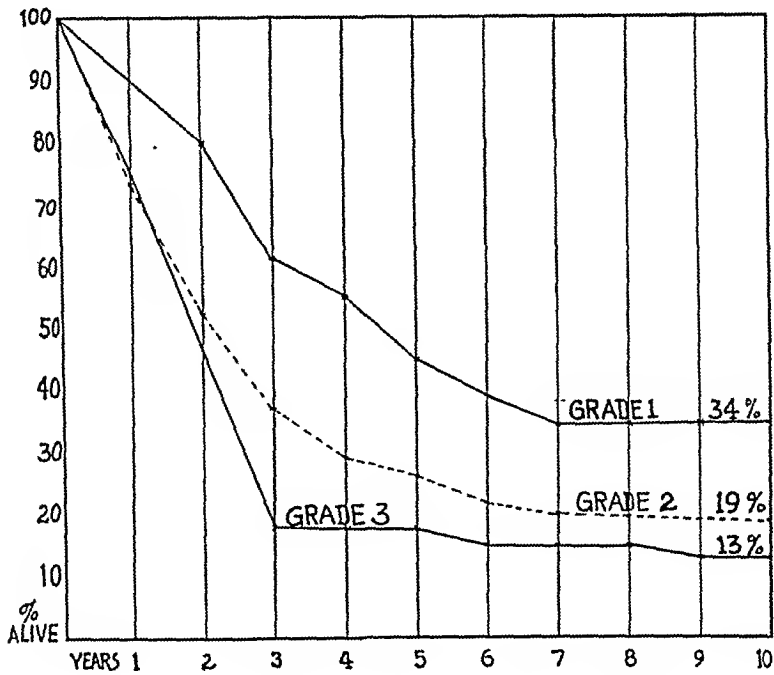
In an effort to unify the information available by the use of the criteria found valuable in the two analyses above, it was decided to establish a combined grading for each case. The grades for nuclear size, nuclear variability, adenoid arrangement and mitosis were added together. If the presence of secretion had been detected, this total was reduced by one. If there was comedo or papillary arrangement, the total was reduced by one for each such factor. This gave a possibility of totals from less than four to 12. Grade I was taken to be any combined total of less than seven, Grade II, from seven to nine, and Grade III, above ten. In this way it was felt that the decisive histologic features were all given some rôle in the establishment of the grade, although their relative values remained unknown and indeterminable.

Graph I shows the results of this method of grading, with a ten year

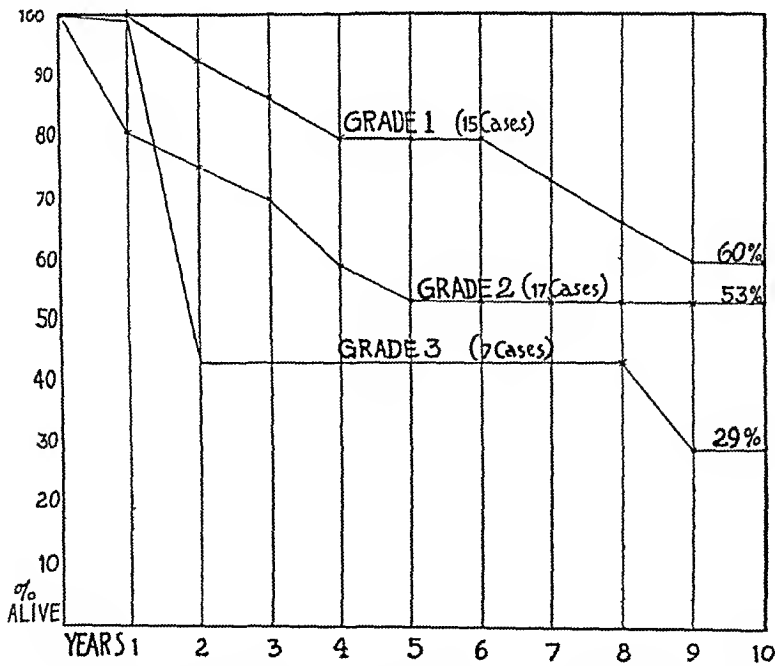
GRADING OF MAMMARY CARCINOMA

clinical follow up. The ten year cure rate varies with grading; 34 per cent for the Grade I group, 19 per cent for Grade II, and 13 per cent for Grade III.

In the cases without axillary metastases, the ten year cure rate is seen by Graph 2 to show for Grade I, 60 per cent; Grade II, 53 per cent; and Grade III, 29 per cent.



GRAPH 1.—Results of grading in whole group (124).



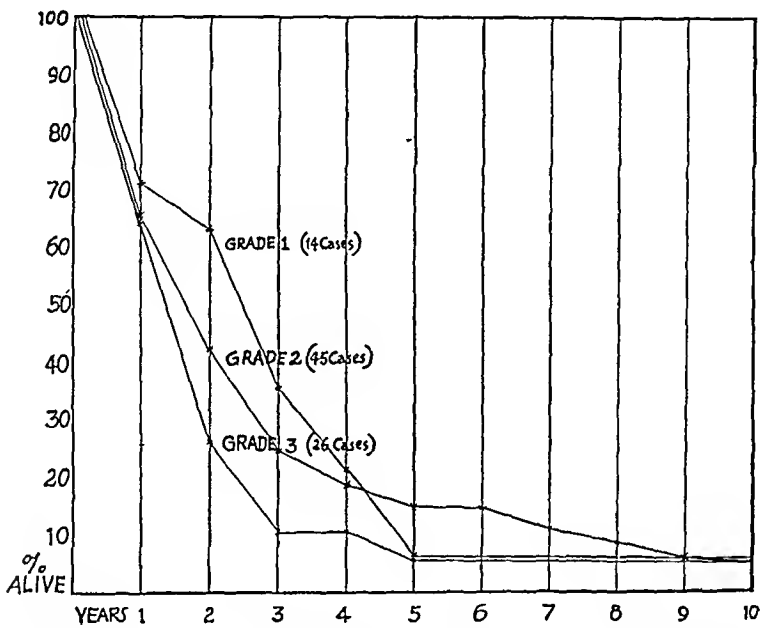
GRAPH 2.—Results of grading in cases free of Axillary Metastasis (39).

In the cases with axillary metastases, the ten year cure rate for all grades is 7 per cent (Graph 3) but the length of life after operation is greatest in Grade I and least in Grade III. This uniformity in eventual outcome is confirmatory of the assumption that the case with axillary metastases usually has

extensions of the tumor beyond the zone of operation, and the outcome is dependent on this invisible factor. However, as Haagensen¹¹ points out, the grades show a relative difference in these cases where operation has been unavailing, just as it does in the early cases where high percentages of cure are found.

CONCLUSIONS

A series of 124 cases of mammary carcinoma treated by radical operation and followed ten years or longer is analyzed by histologic criteria. A definitely lower incidence of axillary metastases at the time of operation was noted in the cases with Grades I and II adenoid arrangement, compared with those growing in solid cords and masses (Grade III). This fact appears to account



GRAPH 3.—Results of grading in cases with Axillary Metastasis (85).

for the previously recognized favorable clinical aspect of the adenocarcinoma. Degrees of fibrosis appeared to exert no influence. Marked lymphocytic infiltration (Grade I) was noted in a group which had a slightly better clinical result than that without this feature. The most significant correlations of clinical outcome and grading appeared in respect to adenoid arrangement, nuclear constancy, nuclear size, mitoses and secretion. The few cases in this series with papillary and comedo arrangement were found to have had a more favorable course.

By a method of combining the information concerning each of the criteria employed, a grading of each case was achieved which shows a definite statistical parallelism with the percentage of ten year cures. This is found to depend on the incidence of cases without axillary metastases. The cases with metastases show uniformly poor ten year results, probably because of the advanced stage of the disease at the time of treatment. Since such cases outnumbered the favorable ones more than two to one in this series, it becomes

evident that the invisible extensions of carcinoma not recognizable at the time of operation form the major controlling factor in the prognosis of the individual case. The histologic analysis indicates nevertheless a relatively slower or more rapid clinical course according to grade of tumor.

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SYMPOSIUM
ON
CANCER OF THE BREAST

AT
THE FIFTIETH ANNIVERSARY OF THE MEMORIAL
HOSPITAL

NEW YORK, N. Y., MAY 25, 1934

Chairman, FRANK E. ADAIR, M.D.

THE EARLY DIAGNOSIS OF BREAST CANCER. ROBERT B. GREENOUGH, M.D.,
Boston, Mass. President, American College of Surgeons.

BIOPSY IN BREAST LESIONS. JOSEPH COLT BLOODGOOD, M.D., Baltimore, Md.
Professor, Clinical Surgery Johns Hopkins Medical School.

THE CLASSIFICATION OF MAMMARY CANCER. JAMES EWING, M.D., New
York, N. Y. Director of the Memorial Hospital.

SURGICAL PRINCIPLES IN CANCER OF THE BREAST. DEAN LEWIS, M.D.,
Baltimore, Md. President, American Medical Association.

THE VALUE OF PREOPERATIVE IRRADIATION IN BREAST CANCER.
FRANK E. ADAIR, M.D., New York, N. Y. Executive Officer of the Memorial Hos-
pital.

EARLY DIAGNOSIS OF CANCER OF THE BREAST

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For the purposes of this discussion we may define "Early Diagnosis of Cancer of the Breast" as the recognition of the disease in its early stages of development, while it is still confined to a single area, in the vicinity of its point of origin, and before it has extended either through the lymphatics, the blood vessels or by infiltration to regions beyond the borders of the mammary gland. Since the rate of growth and of extension of cancer of the breast varies within such extraordinarily wide limits, the factor of time, whether measured in weeks, months, or years, is of relatively little significance in the prognosis unless considered in its relation to the other conditions existing in the individual case. In the 1924-1926 series of cases, recently reported by Simmons, Taylor and Wallace from the Massachusetts General Hospital, 94 cases of *less* than six months' duration gave 41, or 43.5 per cent of five year cures; while 49 cases of *over* six months' duration gave 21, or 43 per cent of five year cures.

The significant feature in early diagnosis, therefore, is not so much the duration of the disease in point of time, as the degree of extension of the disease which has occurred during that period. Taken in this sense, few of us will deny that "early diagnosis" is by far the most significant factor in the prognosis of cancer of the breast, and a brief discussion of this subject may well be justified.

The classic and accepted criterion for the diagnosis of cancer of the breast demands that the epithelial cells of the breast gland shall be shown to have infiltrated beyond the basement membrane of the ducts, or acini, and be identified in the surrounding tissues. In our present state of knowledge, and in spite of opinions expressed to the contrary, I believe that it is wise to adhere to this criterion, and to regard the anaplastic morphology of single cells, or of cells within their normal structural confines, as evidences of hyperplasia, precancerous if you will, but not as justification for the diagnosis of cancer.

For this reason we are forced to regard the small single nodule of cancer in the breast as the primary tumor. From our knowledge of the long period of time required for the production of artificial cancer, we may well believe that the development of such a nodule is probably a matter of years, rather than months. In that sense, therefore, the early diagnosis of cancer of the breast from the point of view of time may be an impossibility, but early diagnosis from the point of view of extension of the disease is an actual fact, and a most important one. In clinics where successive series of cases are reported in a uniform manner, the percentages of early cases appear to be

increasing slowly and surely with the steady advance in the education of the public and of the medical profession.

In 1914, at the Massachusetts General Hospital, only 26 per cent of the operable cases were in the early group in which the axillary glands were found not to be involved on pathologic examination, while 74 per cent showed positive axillary involvement. In the series ending in 1926, the percentage of axillary involvement had dropped to 60 per cent, and 40 per cent of the cases were in the early local stage of the disease. This, I believe, is a clear indication of the value of public education.

The symptoms of advanced cancer of the breast are all too familiar to need discussion here. The earliest recognizable symptom is almost invariably that of a lump or tumor in the breast. Lee recorded that in six per cent of his cases only was pain noted as the first symptom which attracted the patient's attention and led to the discovery of the tumor. Such a single tumor, whether painless or tender, may be cancer or it may be many other things, some of which are recognizable and others not. In my own experience the first symptom which can be considered in any way pathognomonic of cancer is the loss of mobility of the skin over the tumor. This sign is best elicited by gentle pressure designed to move the breast upward or outward on the chest wall. There are, however, exceptions even to this rule; for traumatic fat necrosis, plasma cell mastitis, chronic abscess and infected cysts, especially when situated toward the mid-portion of the breast, may all cause loss of mobility of the skin. Variations of this phenomenon, which is attributable to the shortening of the ligaments of Sir Astley Cooper, are atrophy of the superficial fat, flattening, and in more advanced cases dimpling of the skin, retraction, elevation, or other displacement of the nipple from its normal position, and diminution of the size of the whole breast.

The discharge of clear or brownish fluid from the nipple, and even that of pinkish or bloody fluid, is to be regarded, in my opinion, not primarily as a symptom of cancer, but as evidence of a chronic inflammatory process in the ducts of the mammary gland with more or less hyperplasia of the ductal epithelium, even to the extent of the development of a papillary cystadenoma. Such conditions must, of course, be regarded as of precancerous significance, but the symptom of discharge from the nipple is usually found to have been present for a considerable time before the development of a tumor can be recognized. It has been suggested that microscopic examination of this discharge may make possible the diagnosis of cancer. (I have never seen this accomplished.)

The more common conditions to be considered in the differential diagnosis of cancer of the breast can be classified somewhat as follows:

(1) Benign tumors of the adenofibroma and myxoma group and adenosarcoma.

(2) Nonintrinsic tumors such as lipoma, angioma, lymphangioma, neuro-

fibroma and varieties of sarcoma, including lymphosarcoma, which may occur in the connective tissues of the breast as in other regions of the body.

(3) The chronic inflammatory processes, such as tuberculosis, syphilis and actinomycosis.

(4) The acute, subacute and chronic manifestations of lactation mastitis, including plasma cell mastitis.

(5) Traumatic fat necrosis, deep hematoma and other results of trauma.

(6) The wide range of pathologic conditions which have been described under the comprehensive term of chronic mastitis, including nodular mastitis (mazoplasia), cystic disease (cystophorous hyperplasia), and papillary cyst-adenoma (intracystic papilloma). Such lesions may be accompanied by acute inflammatory symptoms or may be subacute or chronic.

Many of the above conditions have such characteristic signs and symptoms that the diagnosis of their presence can be made with practical certainty, on careful consideration of the patient's history and the direct physical examination. Many of these diseases, however, are also very definitely recognized as of precancerous significance, and the real difficulty of diagnosis lies as a rule not in the failure to recognize the existing noncancerous condition, but in the total inability of the physician to be able to assure the patient by any form of external examination, unsupported by a biopsy, that cancer is not present also.

If we can detect no physical abnormality in the breast, we can indeed report that we find no evidence of disease; but in the presence of any mass or tumor whatever, the possibility of cancer being already present must be considered, either as a natural development of the disease in question, or independent of that disease entirely, and merely concealed by the physical presence of the concomitant lesion.

If we accept this view of the situation, we must be prepared to consider every tumor of the breast of a woman over 20 as involving the possibility of cancer, and in all cases where the positive diagnosis of cancer is not readily made from physical examination, we must so conduct our operative exploration as to obtain certainty of diagnosis by biopsy, without, at the same time, if cancer is present, diminishing in any way the chance for cure, to which the patient is entitled. This, I may say, in the past has not always been done, and is not always done today. Some of the most tragic instances of failure to cure cancer of the breast in early and favorable cases are due to the fact that operation is undertaken for a supposedly benign condition, and the presence of cancer is recognized only after the tissues have been widely contaminated with living cancer cells.

The most recent additions to our resources in the way of diagnostic methods are transillumination, and the "soft part" radiographic examination of the breast in profile. Both methods may be said to be still on trial, and neither has as yet proved itself of such conspicuous value as to weigh heavily in the scale unless the findings are confirmatory of the diagnosis already suggested by the physical examination. In a certain number of cases, however,

each of these methods may be of the greatest service, and a wider employment of them is greatly to be desired.

Another method of using the roentgen ray, namely, as a therapeutic test, has been employed in certain instances. As to the value of this method I cannot speak; I have not tried it and cannot bring myself to feel that it is justifiable. The widely recognized lack of radiosensitivity of breast cancer alone would seem to me to make this procedure a dangerous one on account of the delay and difficulty involved in obtaining a decisive conclusion. We must not forget that the cure of cancer of the breast is still a question of surgical intervention, and the earlier in the course of the disease that operation is performed, the better are the results. We must not forget, also, that in most cases it is quite as important to the patient to be certain that cancer is not present, as it is to confirm a diagnosis of cancer already to be presumed from the physical examination.

The real problem involved in the early diagnosis of cancer of the breast is, therefore, to determine that method of performance of a biopsy which will permit a gross as well as a microscopic examination of the tissues under suspicion, without endangering the patient's chance of cure by surgery if cancer is present. Such a method of examination must give an adequate exposure of all of the abnormal tissue, in order that the patient who is suffering from a benign lesion may be given complete assurance that cancer is not present in her breast.

The radiographic examination of the chest and of the bones is an essential part of the physical examination of any case of tumor of the breast, where the possibility of cancer is to be considered. For this purpose films of the chest, spine, pelvis and shoulder girdle, including the upper ends of humerus and femur, are required. The recent observations of Dresser would appear to make it advisable to include also the examination of the skull.

The physical examination of the axilla, important as it is in early cases, is often inconclusive. This is due in part to the varying depths of subcutaneous fat in different patients, but partly also to the fact that conditions other than cancer may be responsible for the enlargement of axillary lymph nodes to the extent of making them readily palpable. In the three year series reported from the Massachusetts General Hospital ending in 1923, 16 out of 50 cases (32 per cent) in the IA group were recorded as having enlarged glands in the axilla; but on pathologic examination were found to be free from cancer, while in 24 out of 111 cases where the glands proved to be involved, no enlargement could be detected on clinical examination. Under these circumstances the clinical examination of the axilla must be acknowledged to be somewhat inconclusive.

The methods of operative exploration now in use include (1) Direct incision (or excision) of the tumor. (2) Simple amputation of the breast. (3) Aspiration. (4) Punch-trocar method of biopsy. The first consideration is that the biopsy and the operation required should be included in the same

operation. The use of preoperative radiation before biopsy is a precaution widely employed to diminish the danger of an exploratory operation. Such a procedure is amply supported by logic, but I know of no statistical evidence to support this practice. The patient should be in the hospital and should be prepared for a radical mastectomy. A direct incision may be made into the tumor or (if the tumor is small and circumscribed) the tumor itself with a wide margin may be excised. The wound is then immediately packed with formalin (10 per cent) gauze, and the pathologic examination made. If positive for cancer, the exploratory wound is closed, over the formalin gauze; instruments, gloves and dressings are discarded, the operative field is again prepared, and with a new layout the radical operation is performed. If radical operation is not required, the formalinized tissues are excised and the operation indicated is performed. The electrosurgical unit with its cutting and coagulating current can be employed to advantage in performing a biopsy of this nature, especially where excision of the tumor is deemed advisable. It must not be forgotten, however, that cooked tissue does not lend itself well to pathologic examination.

In the years 1918-1926 at the Massachusetts General Hospital, exploratory operations by direct incision or excision of the tumor were performed in 42 cases, with 21, or 50 per cent, five year cures. During this period 310 operations were performed without exploration with 104, or 33 per cent, five year cures. These figures are, of course, not conclusive evidence of safety, for it is usually, though not invariably, the early cases which require an exploratory incision, but the results so nearly approach the results in all of the early and favorable (IA) cases (62 per cent) as to suggest that the exploration diminishes little, if at all, the patient's normal expectation of a successful result.

There are certain cases of supposedly benign lesions, such as cystic disease, which involve so large a portion of the gland that an adequate gross and microscopic examination demands the removal of the whole breast. In such cases the severance of the lymphatic channels between the breast and the chest wall undoubtedly involves danger of contamination of the wound with cancer cells in any but the earliest cases in which cancer is present. In such operations the electrosurgical unit is usually to be preferred to the scalpel. In the nine year period above mentioned, 23 simple amputations of the breast were done, in which cancer was discovered on pathologic examination, and the radical operation was then immediately performed. Of this number, 14 were five year cures (61 per cent). This was before the time of general use of the electrosurgical unit. It must be admitted, therefore, that this method is not always so dangerous as it has been sometimes held to be.

During this same period seven additional cases of cancer were explored through the Thomas axillary incision under a presumptive diagnosis of cystic disease. In all of these cases the radical operation was completed immediately,

and five of the seven (71 per cent) were five year cures, again a suggestion that the unexpected discovery of cancer, in a supposedly nonmalignant breast, need not be disastrous to the patient if proper cauterization, by heat or chemicals, is employed, and the radical operation immediately completed.

A summary of the above figures shows that 72 cases of biopsy gave 53 per cent of five year cures; as against 310 cases of radical operation without biopsy, which gave 33 per cent five year cures.

My own experience with the aspiration and the punch-trocar method of biopsy is very limited, and I must leave their discussion to others more familiar with their use. I am impressed, however, with two points in relation to these methods: (1) the difficulty in being sure that the tissue removed actually comes from the suspected area in the breast; and (2) the difficulty in securing sufficient tissue to permit a positive diagnosis. In any case, one must assume that a negative finding can be held as of little value, and since the safety of the patient requires the certainty that cancer is not present, in many such explorations the purpose of the biopsy would not be obtained.

In conclusion, therefore, the items I would submit for discussion are as follows:

(1) "Early diagnosis" of breast cancer means early in the course of the disease, rather than early as measured by the duration of the symptoms in point of time.

(2) The first symptom of cancer of the breast is usually a lump in the breast.

(3) In the absence of distinctive symptoms in addition to the lump, such as loss of skin mobility, retraction and deformity, or enlarged axillary nodes, an exploratory operation is usually a necessity.

(4) This exploration must be conducted in such a way as not to rob the patient of her chance of cure if cancer is present.

(5) It should permit such an exposure of the tissues, for gross and microscopic examination, as will make it possible to assure the patient positively that she has or has not cancer.

(6) The use of preoperative radiation, and the employment of the electro-surgical unit, provide additional safeguards in cases where direct biopsy is considered to be dangerous.

(7) Delay between exploration and radical operation in cancer of the breast is to be avoided, and the exploration should not be done unless, and until, all arrangements for competent pathologic examination by frozen section and immediate radical operation are available.

(8) Exploration by direct incision is the method to be recommended for general use. In some few cases simple amputation is required.

(9) Operations on supposedly benign breast lesions should be so conducted that, if cancer is found to be present, the patient shall not thereby be deprived of her chance of cure.

BIOPSY IN BREAST LESIONS

IN RELATION TO DIAGNOSIS, TREATMENT AND PROGNOSIS

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THE chief danger of biopsy in breast lesions today lies in a mistaken diagnosis which may lead unnecessarily to the removal of the breast or to the complete operation for cancer. When the surgeon has the benefit of a well-trained pathologist in the operating room, a biopsy is the least dangerous method of determining the benign or malignant nature of the breast lesion. There was presented before the Surgical Section of the American Medical Association at Cleveland a lantern-slide demonstration of the four types of breast tumors which can be excised by cutting through uninvolved breast tissue without seeing the neoplasm and closing the wound without interfering with the symmetry of the breast. These four types are: A distinctly benign lesion; and a border-line lesion; a distinctly malignant lesion; and a Grade IV type of acute carcinoma.

For the benign and the border-line lesion, I urge that after excision of the lump the wound be closed and that the patient receive immediately deep roentgen ray therapy over the axilla and that from five to ten days later the irradiation be continued over the breast and over the wound. During this time sections of the border-line lesion should be submitted to two or more of the most experienced surgical pathologists in breast tumors. When these authorities differ, or agree as to benignancy of the growth, no further intervention is necessary. If the authorities agree on malignancy, then the operator has the choice between depending upon irradiation alone or performing the complete operation for cancer. Apparently the majority of operators, pathologists and radiotherapeutists prefer the complete operation in cases in which the pathologists unanimously agree that the growth is malignant.

An exhaustive consideration on "biopsy" which was presented by me before the Southern Surgical Association (*Amer. Jour. of Surg.*, vol. 24, p. 331, May, 1934), and subsequent dissertations confirm previous statements. There are two excellent reviews on biopsy which give the literature from the time of Virchow to date (Helwig: *Arch. of Path.*, vol. 14, pp. 17-554, October, 1932) and McGraw and Hartman of the Henry Ford Hospital (*J.A.M.A.*, vol. 101, p. 1205, October 14, 1933).

In the discussion of my paper before the Southern Surgical Association, the remarks of Dr. Bradley L. Coley, of the Memorial Hospital in New York, on aspiration biopsy on bone tumors is reported in considerable detail. This method has many advantages. It can be done anywhere under local anesthesia, but the operator must understand his technic. It seems to be without danger. The greatest difficulty is for the pathologist in the interpreta-

tion of the nature of the pathologic process largely by the morphology of the cells. These stained cells can be sent to pathologists who have had greater experience in their interpretation, and if this proves equally satisfactory, aspiration biopsy will ultimately take the place of excision of the nodule or excision of a piece of tissue. From my experience up to date in border-line tumors, I am not yet convinced that aspiration biopsy will be able to compete with the complete excision of the nodule and the examination of immediate and permanent sections. In the Memorial Hospital, with their special training, their negative results, according to Coley, are about 25 per cent.

This paper will be devoted to the discussion of three recent observations on breast tumors which were rather difficult to diagnose. One ultimately proved to be a comedo-adenocarcinoma without involvement of glands. In this case I did not have the courage of my convictions and, after excising the lump, rather a large one, and studying the frozen sections, I performed the complete operation for cancer without any restrictions. The other two cases proved to be benign blue-domed cysts. One felt so much like cancer that after a negative aspiration biopsy I performed the complete operation for cancer. Had I excised this palpable clinically malignant tumor and then bisected the mass, I should have exposed a typical blue-domed cyst and saved the patient from the complete operation for cancer. In the second case of blue-domed cyst which was clinically almost as suggestive of malignancy as the first, I excised a mass larger than in the first and, after removal and bisection, found two blue-domed cysts, the overlapping of which had produced a dark shadow on transillumination.

It is very important to state here that the finding of this comedo-adenoma after the excision of a doubtful lump in the breast, and its recognition in gross and frozen sections, led to the complete operation, because I knew that there are two types of this typical comedo-adenomatous tumor. In one, the less frequent form, the glands are not involved, and it seems justifiable to restrict the operation to the removal of the tumor, while in the second type there are areas of microscopic cancer mixed with the comedo-adenoma, and in this group the glands are involved in about one-half of the cases. In the last case of comedo-adenoma discussed in this paper, the area involved was too large to make complete sections of and exclude evidences of malignant parts. I could, however, have closed the wound and immediately irradiated the axilla while making complete sections. But the area which I had excised, including the nipple, was so large that a normal and symmetrical breast would not have been preserved.

This simply shows how difficult it is for one whose training has been surgical as well as pathologic to force himself to perform a restricted operation for a malignant tumor of the breast. I agree absolutely with the statement of my colleague, Dr. Dean Lewis, which he made during the discussion of breast tumors in the meeting in the Memorial Hospital May 25, that there

should be no restriction if an operation is performed for an operable malignant tumor of the breast.

CASE I.—(Pathol. No. 53384.) *Diagnosis.*—Two blue-domed cysts in chronic cystic mastitis. Clinically doubtful case. The palpable tumor slightly larger than a 25 cent piece transilluminates slightly darker than usual for the blue-domed cyst, and yet not so dark as one would expect of a solid tumor, benign or malignant. (Fig. 1.)

There was nothing in the clinical history particularly helpful. The patient was a married woman, aged 40; no children or miscarriages. Her last menstrual period was about three weeks before she was examined. She first observed that both breasts have been larger than normal in the past six or eight years, since she has gained 30 pounds in weight. On inspection, the breasts and nipples were normal, except the increase in size. In the mid-zone of the upper hemisphere there was found on

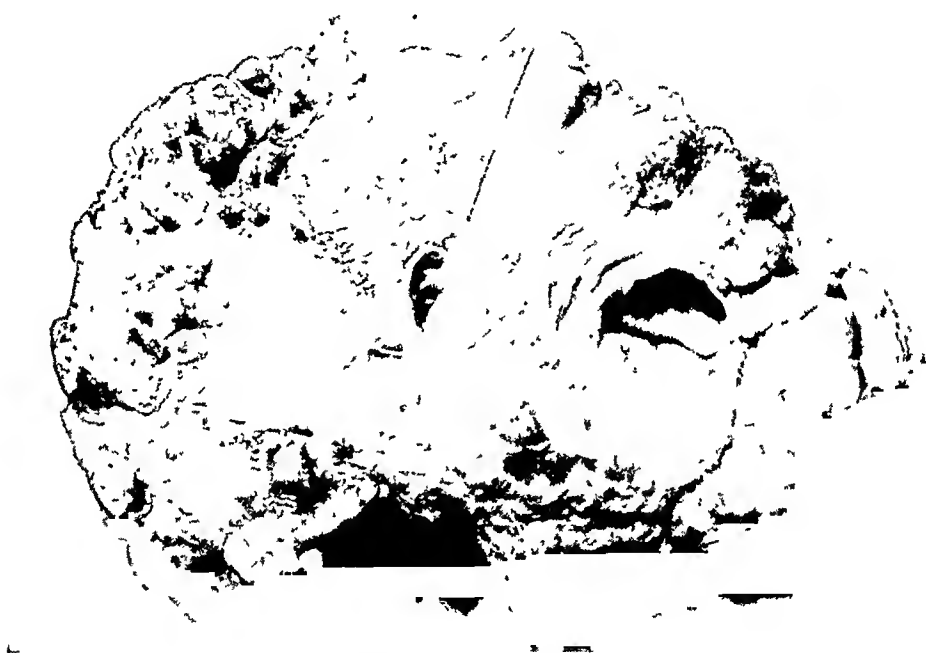


FIG 1.—(53384.) Photograph of excised mass from breast, clinically doubtful. After excision exploration showed two benign blue dome cysts surrounded by adenomatous breast tissue. (See Fig. 2.)

transillumination a darker area, but not so dark as the usual solid tumor. One could make it out, however, and it was in distinct contrast with the clear transillumination of the right breast and the remainder of the left breast. This dark area was the only palpable area in either breast. It was freely movable and felt like an adenoma buried in breast tissue. Remember, we palpated only one tumor and found at operation two cysts. My associate, Doctor Stewart, thought that the tumor fluctuated a little. A tumor of this kind must be regarded as doubtful, aspirated or explored. In view of the fact that it was of five months' duration and there were no other areas in either breast, and the patient was 40 years of age, I decided to aspirate and then explore in the operating room, with the patient prepared for the complete operation for cancer. The patient consented to whatever was necessary.

I decided against aspiration in favor of excision of the lump. As she had a large breast we could excise a fairly large area of tissue without producing any deformity after closing. In cutting through breast tissue we exposed a larger number of elevated pink dots of parenchyma. The frozen sections of this showed chronic cystic mastitis. (Fig. 2). This finding, of course, does not exclude cancer, but it favors the palpable tumor's being a blue-domed cyst. In cutting through the breast tissue between the

nipple zone, we divided numerous dilated ducts just as typical of chronic cystic mastitis as the numerous pink elevated spots. Sections showed dilatation of ducts without comedos or papillomas. This finding also would not exclude a cancer. The specimen was removed and bisected; cutting through the breast tissue first exposed a blue-dome (Fig. 1), then nicked a thin-walled cyst, and cloudy fluid escaped; the wall was smooth; there was no papilloma. Palpating the remainder of the mass, another palpable lump was felt which on exploration proved to be a second blue-domed cyst. The surrounding breast cut through to expose these two cysts was identical with the breast cut through in excising this mass. We had not recognized the second lump until we had explored the first lump. I feel confident that the dark shadow in the transillumination in this case was due to the fact that the cysts were superimposed. I have demonstrated this

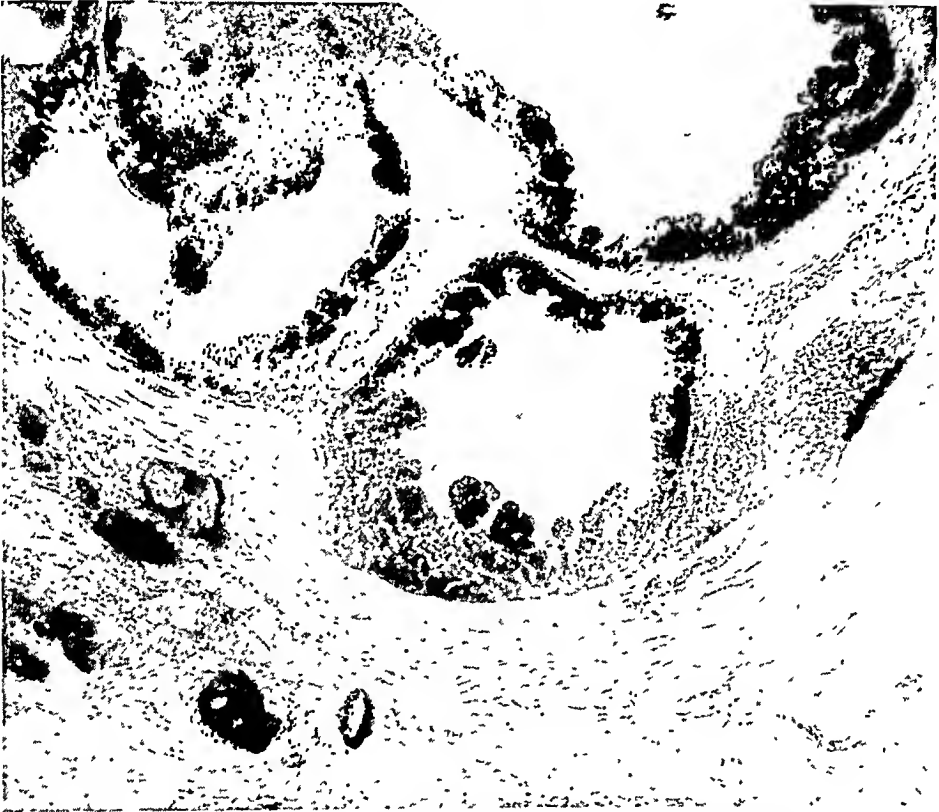


FIG. 2.—(53384.) Section of an adenomatous area in the breast tissue above the blue-dome cyst in Fig. 1.

possibility before. Perhaps, when I have had more experience with aspiration biopsy, I will save more patients from an operation of this character which often means anesthesia and a week in the hospital. But, at the present time, there seems no other way of getting a proper biopsy in blue-domed cysts which, in some ways, are clinically doubtful or even clinically malignant. In this instance a surgeon trained in gross pathology will be certain of his diagnosis from the naked-eye appearances, but there is no question that frozen section confirmation is helpful and, if possible, should be part of the operative diagnostic procedure.

The second case will not be described in detail. In this instance the palpable tumor transilluminated dark and felt like cancer. All my associates and the internes on the surgical service were of the opinion that it felt like cancer. Yet there was no fixation or retraction of the nipple, but the mass palpated like a malignant tumor. It had the typical hard and irregular

surface. I know that in 1 or 2 per cent of blue-domed cysts there have been retracted nipples, dimpling of the skin, or, on palpation, a peculiar sensation so common in malignant tumors. In this case I thought that the palpable mass fluctuated, but very frequently I have thought I have observed fluctuation and found at exploration a small cancer buried in edematous fat. There is no question that the clinical diagnosis of breast tumors is becoming more and more difficult as their duration is shortened, and in many clinics today breast tumors of one month or less duration are becoming the most common tumors observed.

My experience now over a number of years in the employment of transillumination of the breasts is convincing me that it has an equal value with palpation. The most important part about transillumination is a really dark room. The light is of lesser importance. Two or three small pocket electric pencil lights are sufficient. As transillumination is just as efficiently done with the patient standing up as sitting up, a dark closet will answer. The advantage of transillumination on the examining table is that it is better done with the patient lying down as well as sitting up, and this allows transillumination to be employed in both positions.

In the second blue-domed cyst case, the patient was prepared for the complete operation on the operating table, and I aspirated the palpable lump three times, and was able to obtain nothing, and for this reason the complete operation for cancer was performed without an exploratory incision. The patient was not under anesthesia, so there was no necessity



FIG. 3.—(53498.) Gross appearance of typical comedo adenoma of breast excised for microscopic examination. (See Fig. 4.)

for hurrying. I conclude from this and other cases that, especially now, when the incidence of cancer of the breast is on the decrease, and benign lesions are on the increase, it is much wiser in all doubtful cases to perform the exploratory excision of the palpable lump and subject it to bisection, naked-eye study and immediate frozen section. And, I repeat, if the lump is still doubtful or border-line, close the wound as if it were benign, and, while waiting for the decision of a number of special pathologists, start irradiation of the axilla with deep roentgen rays. If the growth is typical cancer as agreed upon by the operator and pathologist in the operating room, perform the complete operation at once unless the pathologist recognizes Grade IV acute carcinoma. Then the wound should be closed and deep roentgen ray treatment begun at once and continued.

CASE III.—(Pathol. No. 53438.) (Figs. 3 and 4.) *Provisional Diagnosis*.—Pure comedo or comedo-adenocarcinoma. Clinically doubtful. *Operation*.—Local anesthesia; aspiration biopsy negative. General anesthesia: Complete excision of lump. Nothing found but dilated ducts beneath the nipple. Complete excision of palpable area with nipple. Bisection of specimen after excision: Typical duct cancer or comedo-adenoma in

center. Confirmed by frozen section. On account of the possibility of fully developed cancer, complete operation performed. Glands in axilla, on gross and microscopic examination, negative.

It is important to state here that this case came under my observation May 28, after I had completed my investigation and repeated restudy of this group of breast tumors classified in the Surgical Pathological Laboratory of the Johns Hopkins Hospital by me as comedo-adenocarcinoma. This was about the forty-fifth case. The first was described in 1893, 41 years ago. It was a clinically benign tumor, and all of these tumors have been identical in gross appearance and microscopic histology.



FIG. 4.—(53498.) Typical comedo and atypical breast lobules. Gross shown in Fig. 3. No evidence of malignancy.

I remember the naked-eye and permanent section appearance of the case I helped to explore in 1893 just as clearly as I do the present case. But this last case received preoperative irradiation, and there were much fewer comedos to be expressed. Otherwise the naked-eye appearance was identical with all the others. The microscopic appearance was slightly different. All surgical pathologists know that irradiation may change the appearance of the neoplastic disease, whether benign or malignant. Tumor cells may entirely disappear. Since successful tumor culture of human cancer tissue we know that we may find cancer nests in the irradiated area which appear normal. But these nests will not grow when cultured. Ultimately the determination of the destruction of the human cancer cell may be accomplished in a positive way by cell culture.

In this case of comedo-adenoma without gland involvement, the clinical history and examination placed it in the doubtful group. The palpable area in the upper hemisphere transilluminated distinctly darker than the normal breast or the blue-domed cyst, but not so dark as a solid benign or malignant tumor. There was no fluctuation in the palpable mass. The nipple was slightly fixed and depressed; there had been intensive preoperative irradiation from April 27 to May 2, and my operation was May 31, 29 days later.

CASE REPORT.—She had observed the lump in the upper hemisphere of her left breast one year. The pain had been slight. A month ago there was bloody discharge from the nipple. Irradiation was begun at once, and there has been no discharge of blood since then, but now and then there has been a cloudy discharge, and at our examination we expressed cloudy and serous material from the nipple, of a type not infrequently seen in chronic cystic mastitis. We decided to explore this palpable area.



FIG. 5.—(51020.) Gross specimen bisected, a clinically benign tumor of the breast excised under local anesthesia. Grossly a doubtful tumor without comedo. Microscopic Fig. 6, a pure comedo adenoma. Immediate post-operative irradiation. Well, July, 1934, almost 14 months. (See Figs. 6 and 7.)

There was nothing distinctly benign or distinctly malignant about it. The history of discharge of blood favored a papillomatous cyst. The duration of the lump of one year favored malignancy. The patient is still menstruating. She is 48. The menstrual periods are changing slightly. There are no other lumps in this or the other breast to suggest chronic cystic mastitis. The lump was sufficiently large to indicate that complete excision would not leave a perfectly symmetrical breast, but the patient begged that the breast be saved even if the symmetry and the nipple were sacrificed.

The patient was prepared for the complete operation. Under local anesthesia there were three negative aspiration biopsies. We could get nothing out of the breast, neither blood, fluid nor cell debris. General anesthesia was then given, and, in view of the history of discharge from the nipple, the nipple zone was included in the area of breast excised. During this excision we passed through normal adenomatous breast. There seemed to be some inflammatory exudate which could be explained by the recent irradiation. When we cut through breast tissue in removing the nipple, we encountered a group of dilated ducts between the nipple and uninvolved breast zone. These ducts

were empty and did not have the characteristic appearance of duct adenoma. The frozen section showed simply dilated ducts, no papilloma, no comedo. I could easily close the defect in the breast and left a but slightly deformed organ. I am confident it would have satisfied the patient, but she had consented to the complete operation, even if I were in doubt. I had no doubt about what I had seen with the naked eye, and in four or five frozen sections, that I was dealing with a pure and relatively benign type of comedo-adenoma. But I had not seen under the microscope *all* the areas, and the area was too large to make frozen sections from every part. Before 1915, in a somewhat similar case, I rested my diagnosis on the naked-eye appearance and found later, in the laboratory, areas of fully developed cancer, and then I performed the complete operation and found the glands to be involved. For this reason, in this case, I decided to perform the complete operation, which was done by my associate, Doctor Cohn. The glands were negative. I wish to repeat, I think this was the safest thing to do. But this comedo-adenoma is a rare tumor. When the tumor is of one month's duration, it is smaller than a 25 cent piece, and the entire tumor can quickly be studied in the frozen sections. I have one such case now. (Figs. 5, 6 and 7.) It is more than two years since the excision of the tumor and immediate postoperative irradiation. The wound broke down and healed by granulation. The patient is well today without palpable glands in the axilla. I might state here briefly that comedo-adenocarcinoma in its pure state does not metastasize to glands. None of these patients has died of cancer. One of them lived over 35 years. All of them lived over five years.

The tumors have varied in size from a ten cent piece to involvement of the entire breast. The breast may ulcerate and produce a fungous tumor. They may be *clinically benign or clinically malignant, they may grow rapidly or slowly*. They are all identical in gross and microscopic appearances. They may be mixed with fully developed cancer of the medullary type, and in many of these cases the only way to make a distinction is with the microscope. The definite presence of comedos in the cut surface of a breast tumor or in the frozen section does not exclude the presence of malignant areas. In the very small tumors typical gross comedos may be absent. Ultimately I think we shall be able to distinguish them in small tumors of the size of a 25 cent piece or less and confine our operation to the removal of the tumor only. We ultimately may even give up postoperative irradiation.

Conclusions.—In those clinics in which the great majority of the patients have observed their breast condition one month or less, in fully 85 per cent of the cases any operative procedure, except an aspiration biopsy, will be excluded by the most careful palpation and transillumination. There is no objection to taking roentgen ray films of the breast. In my experience this cannot compete with transillumination. In these clinics in which only 15 per cent of the patients are placed on the operating table and prepared for the complete operation, the majority of the tumors will be clinically benign and the method of biopsy by excision of the lump as practiced in two of the cases reported here will be employed. This method of biopsy will be employed in some cases clinically malignant, yet doubtful. I see no objection to an aspiration biopsy first, but I would not allow a negative aspiration biopsy to influence anyone in the exploration by excision and examination of the lump by the naked eye and frozen sections. Judging from the tissues sent to me and to the Surgical Pathological Laboratory of the Johns Hopkins Hospital for

BIOPSY IN BREAST LESIONS

examination, surgeons and their pathologists are encountering more difficulties in distinguishing these early breast tumors. The method of biopsy is by excision of the tumor. The surgeon is in doubt as to its gross appearance and the pathologist as to the frozen section. The tumors received are rarely blue-domed cysts or encapsulated adenomas. They are non-encapsulated areas in the breast. The great majority are distinctly benign border-line tumors. A few are malignant.

These border-line tumors are being cut into sections and are submitted three times each year to an increasing number of surgeons, pathologists and radiologists interested in breast lesions, and there is always disagreement, with the majority in favor of benignancy. These border-line breast tumors have all been followed up. In the greater number the breasts have not been removed. None so far has developed any sign of cancer.

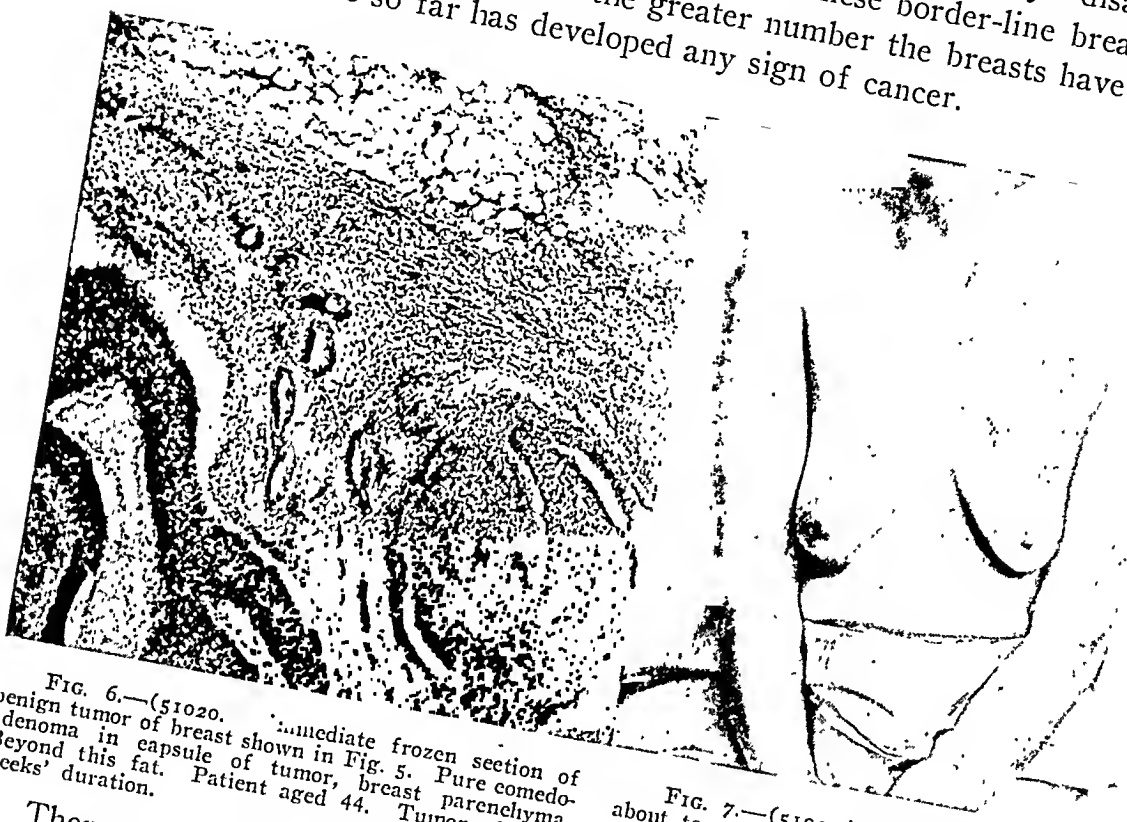


FIG. 6.—(51020.) Immediate frozen section of benign tumor of breast shown in Fig. 5. Pure comedo-adenoma in capsule of tumor, breast parenchyma. Beyond this fat. Patient aged 44. Tumor of three weeks' duration.

FIG. 7.—(51020.) Photograph of patient about ten months after operation. No recurrence. No involvement of the axilla. Clinically well.

There are two cases in which the pathologists differ evenly as to the final diagnosis. In one it is more than three years since the exploratory biopsy, in the other more than two years. One of these cases is a lactating adenoma, the other tumor is a comedo-adenoma, and the difference of opinion is whether it contains areas of fully developed cancer. In this latter case, the comedo-adenoma, the disease was not completely removed, as it involved so much of the breast. There was no pre- nor postoperative irradiation. I have felt this breast within a month, almost three and one-half years after the exploratory biopsy by my associate, Doctor Cohn. There is no recurrence. Concerning these border-line tumors there is a distinct difference of opinion between my associates who are both surgeons and surgical pathologists and between the surgical pathologist in the laboratory.

Until we get a differential stain or until we take up the training of pathologists in the operating rooms of this country, more and more breast tumors as well as other tissues from the operating rooms will have to be submitted to two or more diagnostic clinics during which time the patient may receive irradiation. This is going on now in a very satisfactory manner. There is beginning to be a feeling of responsibility by the larger medical schools and clinics, and they offer more opportunities to young men and women for special study of benign and malignant tumor tissue, as well as in the technic and use of the deep roentgen rays and radium for irradiation. There should be as much opportunity given for the study of tissue diagnosis and irradiation methods as to operative procedures. There is a greater demand today for pathologists and radiotherapeutists than for operators.

The evidence that I have up to date indicates that when a surgeon removes a tumor of the breast and he and his pathologist or he without his pathologist, are doubtful as to the diagnosis, there is no added risk (providing the tumor has been excised by cutting through normal breast tissue, the wound has been closed, the axilla irradiated at once, the breast and the wound irradiated in five to ten days) while waiting, if sections of this doubtful border-line tumor are submitted to a number of the best microscopic diagnosticians. Then if they get the unanimous opinion of malignancy they can perform the complete operation. This statement is absolutely the reverse of what I have advocated in previous publications, but it is forced upon me by facts just as the previous statements were. The breast tumor of one month's duration, even when microscopically malignant, is a different tumor from that present six or more months, and there seems to be additional evidence that pre-operative irradiation, when the tumor is clinically malignant, and after the excision of the small lump for biopsy, offers a better chance of a permanent cure than a complete operation without preoperative irradiation.

The old rule of "When in doubt, perform the complete operation for cancer of the breast" following the rule of Halsted, no longer holds good. Nor should the complete Halsted operation be performed when the breast tumor is clinically malignant. When the breast tumor is clinically malignant, and when the biopsy is doubtful, preoperative irradiation should be the rule.

There is a great difference of opinion among experienced surgeons, pathologists, radiologists and radiotherapeutists on many questions in regard to biopsy and when irradiation should be given, how it should be administered, and how long one should wait before operating after preoperative irradiation. The evidence at hand seems to confirm the following statements: There is no reason for hurrying irradiation. One may take at least three months and then perform the complete operation for cancer. Just how much time one should take for irradiation no one knows yet, but apparently three months is sufficient for at least two thorough courses of the Coutard or some other type of roentgen ray irradiation, with and without the implantation of radon seeds. An agreement on this period of time in which we are justified by the evidence

to wait between the administration of irradiation and the biopsy or the complete operation for cancer, has not yet been reached.

The next point about which there is also much disagreement is, what to do when the microscopic study of the clinically benign or doubtful tumor of the breast leaves the pathologist and surgeon still in doubt. If the pathologist is an experienced one and he has no doubt that the breast tumor is malignant from the microscopic picture, there is no objection to proceeding with the complete operation for cancer. It is possible that perhaps the patient's chances of a permanent cure are better when irradiation precedes the complete operation. If this proves true, then, when the biopsy on the operating table on a patient prepared for the complete operation shows definite malignancy, even in such an instance one should close the breast wound and begin irradiation, deferring the complete operation for three months.

When the glands in the axilla are not involved, the five year cures are about 70 per cent. When the axillary glands are involved the five year cures drop to 25, 20 and 10 per cent according to whether the base, mid or apical glands are involved. These results when the glands are involved depend largely on the skill of the operator. Apparently postoperative irradiation has not influenced five year cures. We have not had enough experience to know what preoperative irradiation will accomplish. However we feel quite certain that if women seek a proper examination within one month, the incidence of cancer will be less than 10 per cent. Between six months and one year it reaches almost 80 per cent. The majority of palpable tumors of the breast of less than one month's duration will be some type of chronic cystic mastitis, and when we exclude from this number those in which we can recognize benignancy without biopsy, by palpation and transillumination, there will remain about 15 per cent of tumors that must be explored, and when these are correctly diagnosed microscopically, much more than one-half of them will be found to be non-cancerous.

The type of surgery for the benign and for the malignant tumor in the breast is settled, but when the operation should be performed is not settled. At the present time, if proper postbiopsy irradiation is given, there is no danger from the delay of the complete operation, during which time sections or pieces of tissue from the mass excised may be submitted to two or more pathologists for diagnosis.

CLASSIFICATION OF MAMMARY CANCER

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A SATISFACTORY classification of mammary cancer would be of great value as an aid in diagnosis, prognosis and treatment, it would facilitate discussion and the spread of knowledge, and by providing a uniform nomencla-

ture it would permit the gathering of comparable statistics on the results of treatment.

Such a classification must be based on pathologic anatomy, histogenesis, and structure, which determine the gross appearance and course of the disease, but it must fit the clinical aspects of the disease which impress the surgeon who has to deal with the patient. It would seem that present knowledge is sufficient to permit the adoption of some scheme which would cover all but the very rare varieties of cases. We submit the following plan for consideration.

(1) *Adenocarcinoma Arising in Cysts*.—This is the most characteristic type of mammary cancer. It arises in cysts, in the walls or in papillary growths within cysts, or it arises from an isolated segment of breast tissue. The architecture of the blood system in these tumors is dendritic, so that they grow expansively, displacing rather than infiltrating the breast tissue, and tending to produce a single multilobed compact mass. In any case, the growth is encapsulated or circumscribed, and infiltration occurs only in the later stages.

These tumors will grow to large dimensions, often rapidly. They protrude and often fungate through the skin, with ulceration, bleeding, and sloughing. The invasion of lymph nodes is delayed, but only in accordance with the grade of malignancy. Many of them long spare the nodes, so that the prognosis is generally better than the extent of the local disease suggests.

(2) *Mucous or Gelatinous Carcinoma*.—This is an adenocarcinoma with mucous degeneration of stroma and fat tissue. The mucous change often retards the growth of the tumor cells, so that the total duration is distinctly longer than that of other adenocarcinomas. It presents the same gross appearance as ordinary adenocarcinoma, but the mucus gives bulk and elasticity to the tumor, and when it is very abundant, the tumor cells may largely disappear and the tumor areas are largely represented by mucous cysts.

(3) *Duct Carcinoma*.—This variety occurs in two main forms. (a) *Localized duct carcinoma*, and (b) *diffuse duct carcinoma*.

(a) *Localized duct carcinoma*. *Comédo-carcinoma*. This condition occurs in small breasts without much fat tissue, in which a segment of ducts, often about the nipple, or in any segment, becomes slowly distended with inspissated secretion which exudes from the cut section as yellowish or dark material. The breast is usually reduced in size, but a hard palpable tumor is present, and the nipple is early retracted.

(b) *Diffuse duct carcinoma*. This condition arises in large fat breasts in which the ducts are held apart by the fat tissue. It begins in a segment of a duct, and extends along the duct system, even involving the entire breast, which becomes enlarged, swollen, edematous, with pigskin appearance, but a definite localized tumor is missing.

Small infiltrating and metastasizing duct cancers may arise in any portion of the breast, and when highly malignant they are responsible for most of the unexpectedly bad results of radical operation.

There are all grades of malignancy in duct cancers, but infiltration of breast tissue and extension to lymph nodes are relatively early.

It is well known that the majority of breast cancers arise from duct epithelium, but in the cases here classified, the relation of the process to the ducts and its extension along the ducts is so prominent as to yield peculiar anatomic and clinical features. It is not impossible that peculiar etiologic factors are also involved.

(4) *Paget's Disease*.—This is essentially a duct cancer, which begins in a segment of one or more large ducts, usually in or beneath the nipple, and extends outward over the nipple and areola, or downward to the deeper portions, and often in both directions. It may be found exclusively in nipple and skin, or only in the ampulla, or only in the large terminal ducts. It may grow slowly and long fail to infiltrate the breast tissue, but it may spread along the ducts and prove as malignant as any form of mammary cancer. A definite tumor is often missing.

(5) *Carcinoma Arising on Chronic Mastitis*.—A definite grade of chronic mastitis occurs in a considerable proportion of breasts which are the seat of carcinoma. Usually the remaining breast shows simple atrophy, with or without fat hypertrophy. Hence, comes the rule that a single very hard nodule in an otherwise normal breast is nearly always cancer.

In the present group of cases the changes of chronic mastitis are prominent, and the carcinoma appears to be the sequel of the mastitis. The mastitis may take the form of any one of the three main varieties, cystic, nodular, or diffuse. One or more of the cysts, nodules, or thickened ducts becomes enlarged, very hard, more or less fixed, or adherent to skin, and presents the usual features of infiltrating carcinoma. Multiple foci of carcinoma are not uncommon. A common condition is a tight nipple, thickening of the large ducts, then a zone of cysts or hard nodules, and on the outskirts of the breast a single very hard nodule of definite carcinoma.

The histologic types and grades of malignancy in carcinoma arising on chronic mastitis vary widely. Ducts, acini, sweat glands, the walls of small cysts, papillary adenocarcinomas growing into cysts, all contribute a quota. The histologic structure is often mixed and confusing. As a rule, the grades of malignancy average lower than in most other varieties, but the disease is often fully malignant and dangerous.

(6) *Sweat Gland Cancer*.—Many of the more cellular and malignant carcinomas arising from sweat glands are difficult to distinguish histologically from duct cancers, and the clinical features are not peculiar, but when the cancer arises from the glands on the outskirts of the breast, or when the tumors are of moderate malignancy, they constitute an easily recognizable clinical variety. These tumors arise in or just beneath the skin, on the edges of the breast, along the mammary fold, and slowly protrude and ulcerate through the skin. They are firm but not fibrous, smooth, yellow, and generally dry and free from necrosis and edema. Cellular tumors of sweat glands produce any of the common anatomic or clinical varieties, except Paget's disease. They are often mucous.

(7) *Inflammatory Carcinoma*.—This is clinical variety, characterized by rapid growth, diffuse spread over wide areas of skin, with erysipelatous reddening, heat, and edema. It usually arises on a basis of a preexisting diffuse infiltrating duct carcinoma. It is sometimes associated with some secondary infection, but its exact causation is unknown. The reddening of the skin is due to diffuse infiltration of the dermal lymphatics or blood vessels, by rapidly growing tumor cells, accompanied by edema and lymphocytic infiltration.

Many cases of carcinoma of the breast show some signs of inflammation of the skin, but the tendency to identify many such milder cases with true inflammatory carcinoma is to be avoided.

(8) *Histologic Designations*.—The chief source of confusion in the nomenclature of mammary cancer is the tendency to employ histologic terms instead of well defined anatomic and clinical types.

Medullary carcinoma refers to any very cellular tumor, usually an adenocarcinoma.

Scirrhus carcinoma is a clinical term for advanced fibrocarcinoma involving much of the breast with atrophy.

Fibrocarcinoma refers to any highly fibrous structure, which may arise in almost any type of tumor.

Cancer *en cuirasse* refers to the encasement of the chest wall in cancer tissue, usually of fibrous type.

Carcinoma simplex designates the usual structure of fully developed infiltrating carcinoma.

None of these terms should be employed as the primary entry for any clinical or anatomic variety of mammary carcinoma.

SURGICAL PRINCIPLES IN CANCER OF THE BREAST

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THE operative treatment of carcinoma of the breast dates back almost to the beginning of medicine. Astley Cooper in the early part of the last century recognized the importance of the involvement of the axillary nodes and removed some, but at that time no radical operation was attempted, although I believe that the desirability of the radical removal of the nodes is indicated in the article which he published.

Lister deliberately planned and performed a radical operation and, as far as I know, this is the first instance in which a radical removal and block dissection of the axillary nodes was carried out. Some years later Heidenhain, Willy Meyer and Halsted devised operations in which a block dissection of the axillary contents and a radical removal of the breast was attempted. While the technic varied considerably, the ultimate object was the same. In

one operation the dissection was carried from below upward, the axillary dissection being done last; while in the other operation the axillary dissection was performed first, as the bleeding is much better controlled when the vessels are ligated first. They are no longer encountered repeatedly as when the dissection is carried from below upward.

Since these operations were devised, there has been at times a tendency to perform a less radical operation. There has been a great deal of discussion as to whether the pectoral muscles should be sacrificed, or as to whether it is not the best procedure to remove the pectoralis major and leave the minor. Bryant of London said some years ago that he had not seen a recurrence of carcinoma in the pectoralis major, and that, if the fascia covering the pectoralis major were removed, the necessary precaution to prevent recurrence in the muscle had been taken. Recurrences have been observed in the pectoralis major. The function of the arm is not interfered with when both muscles are removed, and a satisfactory axillary dissection cannot be made unless they are removed. In some of the discussions which have been carried on Groszman's lymphatic path seems to have been forgotten. The lymphatics described by Groszman pierce the pectoralis major muscle and empty into lymph nodes described by Rotter which are found in the upper part of the axilla. These cannot be satisfactorily removed unless the axilla is carefully exposed after both muscles have been divided. As there is no alteration in the motions or interference with the same, there is no reason why these muscles should not be removed.

In the operation, in order to prevent limitation of motion, an axillary skin flap should always be made, which can be tucked into the axilla and so applied that the motions of the upper extremity will be perfectly free.

Too much rather than too little skin should be removed, and not infrequently skin grafting will have to be resorted to. Removal of skin prevents recurrences in the form of lenticular carcinoma.

Surgical elephantiasis remains one of the distressing sequelae. I think that I have seen it most frequently after incomplete operations, especially in those cases in which the apex of the axilla has not been dissected. It occurs also in those cases in which serum has been allowed to accumulate and after infections. A clean dissection with a sharp knife, without tissue damage, is the best safeguard against this sequela. In some cases no explanation can be given, and in such instances there may be anomalous distribution of the lymphatics.

There is a tendency to limit the degree of radicality, and I do not believe that as radical and good operations are done, as a rule, as when this radical procedure was first undertaken.

A radical operation should be performed, and no degree of radicality, based upon the size of the tumor, practised. An operation should be resorted to in all cases, except when there is no hope of effecting a cure. Some cases which I have operated upon with little hope have survived long periods.

THE VALUE OF PREOPERATIVE IRRADIATION IN BREAST
CANCER

STUDIES ON EIGHTY-ONE OPERABLE CASES

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AND

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IT HAS been most difficult to evaluate the statements made by various authors on the value of preoperative irradiation in cases of breast cancer. Some authors, especially radiologists, have enthusiastically and unqualifiedly stated preoperative irradiation to be of great value without giving their criteria for such conclusions. On the other hand, some surgeons have been completely unwilling to accept the considered thought of cautious students of irradiation. The truth must lie somewhere between these points of view.

In an effort to evaluate preoperative irradiation we have taken 81 patients having operable mammary cancer and subjected them to preoperative irradiation. Part of them were treated (39 cases) by the radium element pack; while 42 cases were treated by the high voltage (200 K.V.) roentgen rays. Approximately a two to three months' period followed the completion of the irradiation, when a radical amputation was performed. Careful tissue studies were then made of the residual tumor. Certain deductions have been drawn as to the efficacy of the type of the irradiation applied, and also as to the amount supplied.

In each case here reported a positive aspiration biopsy complemented our clinical diagnosis. There are some who may feel that aspiration biopsy is not a certain method of biopsy; however in the Memorial Hospital it has come to be fully relied upon. Unless we have a report of a positive cancer by this method, we have excluded that case from these studies.

Radium Element Pack Cases.—Thirty-nine cases were subjected to treatment using the radium pack (4 Gm.) at a distance of 6 cm. Five ports were used, namely: (1) The breast mesially; (2) the breast laterally; (3) the axilla anteriorly; (4) the axilla direct, and (5) the axilla posteriorly. By this method, the tumor in the breast was cross-fired in two directions while the axilla was cross-fired in three directions. Fifteen cases were subject to treatment using 20,000 M.C.H. per port; two cases, to 22,000 M.C.H. per port; 20 cases, to 24,000 M.C.H. per port; one case, to 28,000 M.C.H. per port, and one case, to 44,000 M.C.H. per port. In some instances as a result of such intense irradiation at such a short distance, the skin denudation persisted, becoming a chronic nonhealing ulcer. In these cases the operation did not take place before a three or four months' period after irradiation ceased. The radical Halstead operation was then performed, removing the muscles and all axillary contents. Careful studies were then made and revealed that there had been a most striking effect on the original tumor in a

large part of the cases. Of the 39 cases so treated it was found that eleven, or 28 per cent, of the tumors had completely disappeared, so that no trace of cancer tissue remained in the breast after the most careful studies had been made.

Scale of Irradiation Effect.—These studies have led us to the conclusion that a scale of irradiation effects would be of great value; the following was therefore devised:

R.E. 0: Signifies that irradiation destruction is most incomplete and has been minimal. It may signify that there was complete destruction in one area with persistence of viable disease in another area.

R.E. 1: Signifies that we have the minimal effects of irradiation such as atrophy, hydrops and slight sclerosis.

R.E. 2: Signifies a more marked condition but a similar one.

R.E. 3: Signifies that the process of irradiation destruction has been extremely marked, and that there is a question whether the tumor cells are viable or not. It will remain for the element of time to prove whether this R.E. 3 group is capable of regeneration or metastasis. Doctor Ewing is of the impression that the cases falling into this group may eventually be completely cured and incapable of recurrence. We are taking the position, at least for the present, that this group may be capable of recurrence.

R.E. 4: Signifies that after a most careful study has been made of tissue taken from many portions of the breast, there is no sign of any demonstrable cancer.

Following out this same idea as above applied to the breast, we have made similar studies on the axillary nodes. Their irradiation classification scale would be N. 0; N. 1; N. 2; N. 3; N. 4. The clinical studies of these cases, although they parallel the microscopic studies in many instances, are not as a rule a reliable criterion. The following is a table showing the clinical changes which took place in the breast and in the axillary nodes.

TABLE I
RADIUM ELEMENT PACK

	Breast		Nodes	
	Cases	Percentage	Cases	Percentage
Complete clinical disappearance.....	15	40	6	33
Only residual thickening.....	11	30	—	..
Marked reduction.....	9	23	8	44
No change.....	3	7	4	22

The following table gives the scale of irradiation effect according to the above described criteria:

TABLE II

Radiation Effect (R.E.)	0	1	2	3	4	BREAST
Cases.....	11	7	3	7	11	
Percentage.....	28	18	8	18	28	
RADIATION EFFECT						NODES
	Cases.....	11	1	1	2	
	Percentage.....	73	6.5	6.5	13	

If it were possible to add R.E. 4 and R.E. 3 there would be 46 per cent of the cancers in the breast which received these profound changes. Similarly, in the case of the nodes, if we could add N. 4 and N. 3, there would be 19.5 per cent, which is one in five cases.

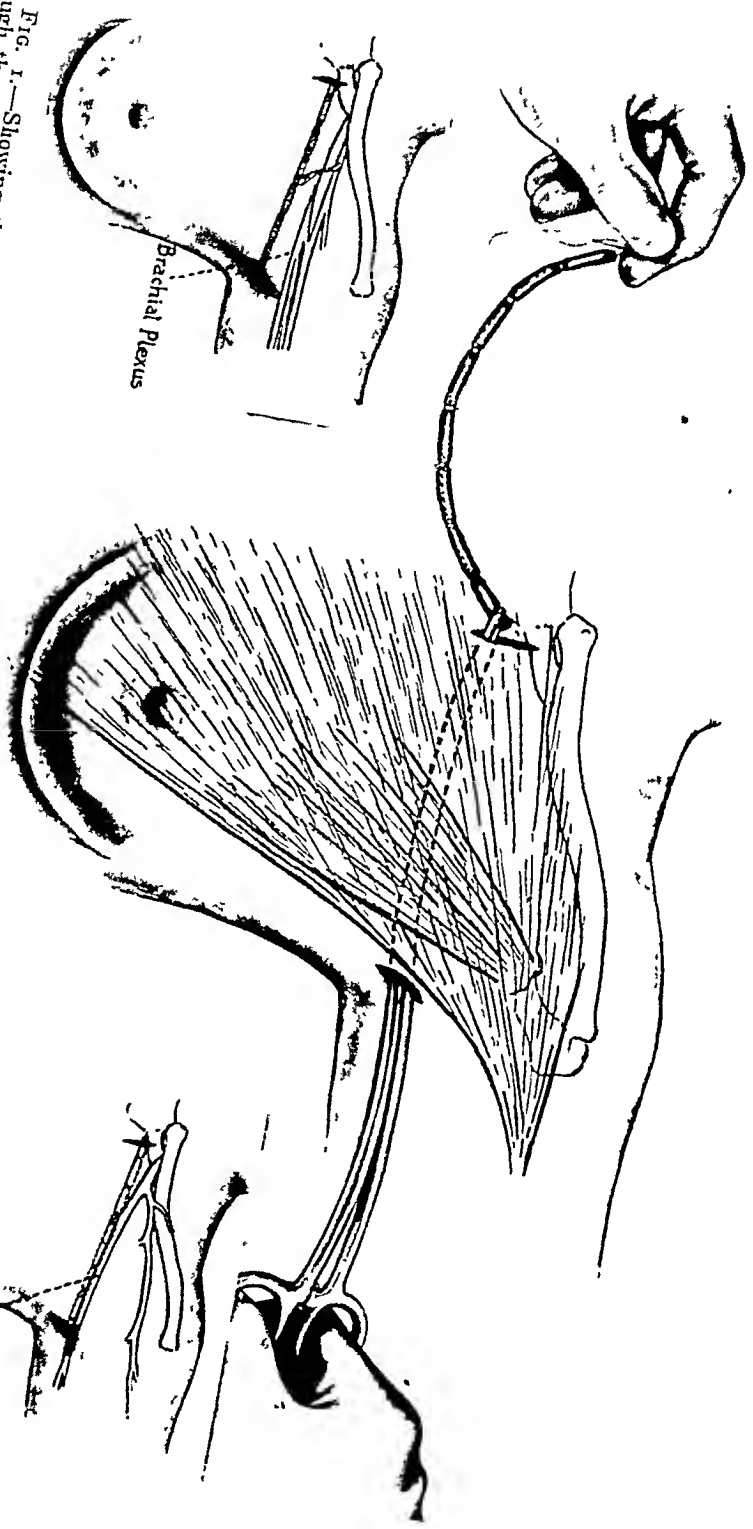
It is perfectly obvious that we are failing to cure axillary nodes in a very high proportion of the cases. It is also obvious that we are curing cancer situated in the breast itself in better than one out of four cases by such an external irradiation method as this. On account of these facts, we have devised a new method of radiating the axilla by the placing of a radium string across it which we hope, after sufficient experimental work has been done, will accomplish a much greater sterilization than has heretofore been possible.

New Method of Radium String.—A rubber catheter is employed. Into this catheter are inserted in tandem form, six silver tubes, containing radium emanation each 16 Mm. long. These capsules are separated from each other by a cord knot so that there is a space between each of the six capsules of about 3 Mm. each. The filter of the capsule is equivalent to one millimeter of platinum. The length of the radium bearing area is about 11 cm.

Under local anesthesia a long uterine dressing forceps with a slight curve at the end of the blade is pushed through the axillary fascia, parallel to the axillary vein going behind the pectoralis major muscle and the pectoralis minor muscle. The point of the clamp is then brought up through the pectoralis major muscle and on through the integument at the edge of the sternoclavicular joint (Fig. 1). This can easily be accomplished by holding the arm out at right angles to the body. Novocain is used only at the site of entrance through the skin of the axilla, and also at the site of emergence at the sternoclavicular joint. The point of the dressing forceps, while still *in situ*, then grasps the free end of the catheter, which is then pulled backwards through the tract by the forceps. The radium string is held accurately in place by one suture. It is not necessary to make more than a 1 cm. skin incision at either end. If one proceeds carefully and slowly with the point of his clamp turned caudally, he will not run the risk of tearing a hole in the subclavian vein. One must also advance the point of the clamp carefully in order to avoid the possibility of tearing one of the smaller veins which cross the axilla emanating from the subclavian and axillary veins. We have employed this method of axillary irradiation in 30 cases. In no instance have we encountered any difficulty with the axillary vein or its branches while placing the radium string (Fig. 2). We, therefore, do not hesitate to recommend this procedure. Naturally we started most cautiously in these studies for fear of obtaining a brachial neuritis on account of the proximity of the brachial plexus to the axillary string. In these 30 cases we frequently consulted our physicist, Doctor Quimby. We began by using three S.E.D. 3 Mm. from the source of the radium. This amount has been gradually increased to seven S.E.D., and during this time, no case has shown neuritic symptoms. It may be possible to run this amount of irradiation up to where we are

IRRADIATION IN BREAST CANCER

Fig. 1.—Showing the uterine dressing forceps behind the pectoralis major and pectoralis minor muscles. The tip protrudes through the skin near the sternoclavicular joint. It grasps the end of the rubber catheter which contains the six radium capsules. The other insert shows the relation of the radium string to the axillary vein.



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FIG. 2.—Showing the relative position of the radium string in relation to the injected (skiadon) axillary and subclavian veins in the living subject.

obtaining a cylinder of sterilization which may be three to five cm. in diameter. If this becomes possible, without the production of neuritis, this method will be a distinct advance in radium therapy.

These cases are being reported from the standpoint of experimental studies. It remains to be seen what will be the effect five years hence on increased cures over our present surgical results, namely 35 per cent, where preoperative irradiation is not employed.

In the study of these cases treated by the radium pack, it was found that where 20,000 M.C.H. was employed per port, that we had no case of a persistent ulcer of the skin. However, when we went up to 24,000 M.C.H. per port, we found that of the 20 cases so treated, 12 or 60 per cent had a persistent ulcer of the breast. Furthermore, we found where the cases were treated by 24,000 M.C.H. per port, that our largest group of completely destroyed tumors occurred. This was likewise true in the successful destruction of the nodes. One of the disadvantages of treating the mammary gland by these higher doses of radium is the complication which ulceration makes at the time of operation. If the breast is infected, it is very easy to obtain lymphedema of the arm. In most of the cases where there had been a R.E. 3, and R.E. 4 effect, it was impossible to grade the cancer on the scale of malignancy, as destruction had proceeded too far.

The size of the tumor appears to play a rôle. It seems from a study of the lesions that a tumor having a diameter of 2 or 3 cm. has a much better opportunity of complete regression than one of great bulk. In the latter case it frequently happens that the large part of the tumor is completely necrotic but the very periphery may be viable. We have taken arbitrarily from two to four months after the completion of irradiation as the time chosen to do the radical amputation. This was chosen partly on account of the fact that most irradiation effects are accomplished during this period. In the cases treated by the high voltage roentgen ray, the skin, although markedly damaged, usually cleared up within two to three weeks after the completion of treatment. The radium pack produces a slower skin damage than the high voltage roentgen ray. One disadvantage of the radium element pack is that the ports are not of sufficient size, so that in a large woman with pendulous breasts, it is not an instrument which as completely covers the breast and its drainage areas as does the roentgen ray. We believe that one of the main advantages of the radium pack is its effectiveness in superficial tumors. The axilla is such a large space that the roentgen ray may prove to be a better agent for treatment.

200 K.V. Roentgen Rays.—Forty-two operable cases were treated by the 200 K.V. roentgen ray machine. To some we gave 1,200 *r.* to each of six ports; in some cases, 1,500 *r.* per port were given, and in a few, 1,800 *r.* per port. Three hundred *r.* were delivered to each of three ports daily until the required amount was given. One-half Mm. of copper filter was used. This dose was somewhat lighter in most instances than the doses delivered by the radium pack. However, even though the doses were lighter, there

were seven out of 42 cases that had complete microscopic disappearance of the tumor.

The following table shows the clinical changes taking place in the breast and in the axillary nodes:

TABLE III

200 K.V. ROENTGEN RAYS

	Breast		Nodes	
	Cases	Percentage	Cases	Percentage
Complete clinical disappearance.....	13	34	8	28.5
Only residual thickening.....	4	11	..	....
Marked reduction.....	8	21	8	28.5
No change.....	13	34	12	42.5

The following table gives the actual scale of irradiation effect:

TABLE IV

200 K.V. ROENTGEN RAYS

Radiation Effect (R.E.)	0	1	2	3	4	BREAST
Cases.....	18	5	4	8	7	
Percentage.....	43	12	10	20	16.5	
Cases.....	16	6	1	2	0	NODES
Percentage.....	64	24	4	8	..	

CONCLUSIONS

It is shown that the radium element pack as applied in a group of 39 cases destroyed the breast cancer in 28 per cent of the cases. In a similar group of 42 operable cases treated by the 200 K.V. roentgen ray machine the breast cancer was destroyed in 16.5 per cent. It is also shown that external irradiation as applied in this series did not effectively combat axillary disease; and this fact points to the necessity of giving additional interstitial irradiation. A method is above described which will unquestionably improve our results. A new scale of irradiation effects is described; it has been of assistance to us in these studies. It is our impression that eventually irradiation will be given in smaller doses, and extended over a longer period of time; and that end-results will be improved thereby.

In the light of the studies here reported it is our impression that the five-year cures will be definitely increased by the employment of preoperative irradiation; and that it should be employed in all instances of cancer of the breast complicated by pregnancy; in cases with bulky axillary disease; and in those of cancer in young women.

NOTE. We are indebted to Doctor Duffy for seeing that the problem was carried out as outlined in the Radium Pack Department. We are likewise indebted to Doctor Herendeen for similarly carrying out the details of the problem in those cases treated by roentgen rays; and to Doctor Quimby, we are deeply obligated for encouraging us and guiding us in the details of the physicists' problems.

BONE GROWTH AND REPAIR*

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GROWTH and repair are properties of living matter that have a great deal in common, and a study of one may yield results of importance in the understanding of the other. In certain lower forms of animal life and in the least specialized tissues of higher forms, repair may be almost identical with growth except in the matters of time, velocity and the nature of the stimulus bringing it about. Thus, repair following amputation of the leg of a salamander or the tail of a tadpole may proceed to the point of complete restitution of the missing part with its various types of tissue, and repair following injury of certain epithelial and connective tissues in man may approach the same order of perfection. Bone is one of the tissues in which repair simulates growth both in its physiologic and morphologic processes to a very considerable degree.

Bone growth takes place by two types of ossification: ossification through cartilage and ossification through fibrous tissue or membrane. The bones of the vault of the skull, parts of all the facial bones and the clavicles are performed in membrane and grow by fibrous ossification. The reason for this is to be found in comparative anatomy and paleontology. The earliest vertebrates or selachii which included the sharks had a cartilaginous skeleton. The head had cartilaginous jaws and base of the skull, but the vault of the skull was composed of membrane. In the succeeding phylum which included the bony fishes a layer of dermal bone or exoskeleton appeared over vault of skull, jaws, throat and gill regions. The prevailing theory, according to Romer,¹ is that this developed as a defense mechanism against the deadly attacks of their eurypterid or crab-like enemies. This dermal bone disappeared in places in early land animals and all that is left in man is in the vault of skull, face bones and clavicles, which structures have gradually sunk beneath the skin and articulated with the endoskeleton. They are a lasting memento of the successful struggles of our earliest vertebrate ancestors against enemies that became extinct hundreds of millions of years ago.

The rest of the bones, while preformed in cartilage, grow partly by enchondral ossification and partly by fibrous ossification. Increase in length of shafts through the epiphysial lines and in size of the bony centers of the epiphyses is by enchondral ossification, while transverse growth of shafts and transformative growth of cancellous bone in the metaphyses and epiphyses is by fibrous ossification. As growth continues the enchondrally formed bone, which is increasingly farther separated from the epiphysial line, is gradually replaced by bone formed directly by fibrous ossification. When maturity is

* The Arthur Dean Bevan Lecture of the Chicago Surgical Society, 1934.

reached all that remains of the enchondrally formed bone is the major portions of the epiphyses and metaphyses.

Each pair of long bones differs in the relative amounts of longitudinal growth taking place at the two ends. These amounts have been variously determined as by measurements after arrest of longitudinal growth either experimental or accidental, after implantation of metallic markers, after the administration experimentally of madder or elizarin red to discolor the newly formed bone and after the formation of dense transverse metaphysial bands or lines of bone during periods of phosphorus therapy, or after severe illnesses, as scarlet fever. Digby² prolonged the axis of the nutrient artery of adult bones to the center of the marrow cavity, at which point ossification presumably began and measured the distance from there to either end of the shaft. His amounts of growth at the two ends of the shafts were as follows: Femur, u.e. 5 in., l.e. 11 in. Tibia, u.e. $7\frac{1}{2}$ in., l.e. 5 in. Fibula, u.e. $7\frac{1}{2}$ in., l.e. 5 in. Humerus, u.e. $9\frac{1}{2}$ in., l.e. $2\frac{1}{2}$ in. Radius, u.e. 2 in., l.e. 6 in. Ulna, u.e. $1\frac{3}{4}$ in., l.e. $5\frac{5}{8}$ in.

Measurements in 25 children from transverse lines or bands produced by phosphorus medication or by illnesses have been made by Dr. C. Howard Hatcher in the University of Chicago Clinics, which, in percentages of growth gave the following results: Femur, u.e. 21 per cent, l.e. 79 per cent. (Fig. 1). Tibia, u.e. 56 per cent, l.e. 44 per cent. Fibula, lines are often indistinct before appreciable growth increment, but when distinct the percentages approximate those for tibia. Humerus, u.e. 84 per cent, l.e. 16 per cent. Radius, u.e. 18 per cent, l.e. 82 per cent. Ulna, uncertain because of early fading of lines, but similar to radius. These figures approximate those obtained by Digby for humerus and femur but show a greater difference for radius and more nearly equal growth for tibia. Operative arrest of longitudinal growth by excision of the epiphysial cartilage line and sliding bone grafts on either side has been used in selected cases to retard growth in the longer limb, in case of shortening from disease or injury and thus equalize limb length (Phemister³). This necessitates a knowledge of the amount of growth at each epiphysial line in order to determine the appropriate age for operation and the number of epiphysial lines to be fused. Experience has shown that estimations may be made that are of sufficient accuracy to yield satisfactory results.

The age of completion of longitudinal growth for each bone varies directly with its size and with the relative amount of growth from either end. In general the shorter bones stop increasing in length first, as does that end of a bone from which the lesser increment occurs. The greatest difference between ends is seen in the humerus. At the lower end where 15 to 20 per cent of the increment takes place, growth stops at 13 to 15 years, whereas at the upper end where the other 80-85 per cent takes place, it stops at 18 to 20 years. The bones of females reach their full longitudinal growth on an average of two years earlier than males. The velocity of growth varies considerably with

age and with the date of establishment of puberty. There is a growth spurt during approximately the two years preceding puberty which, according to Baldwin and Todd, is somewhat less marked in the bones of the extremities

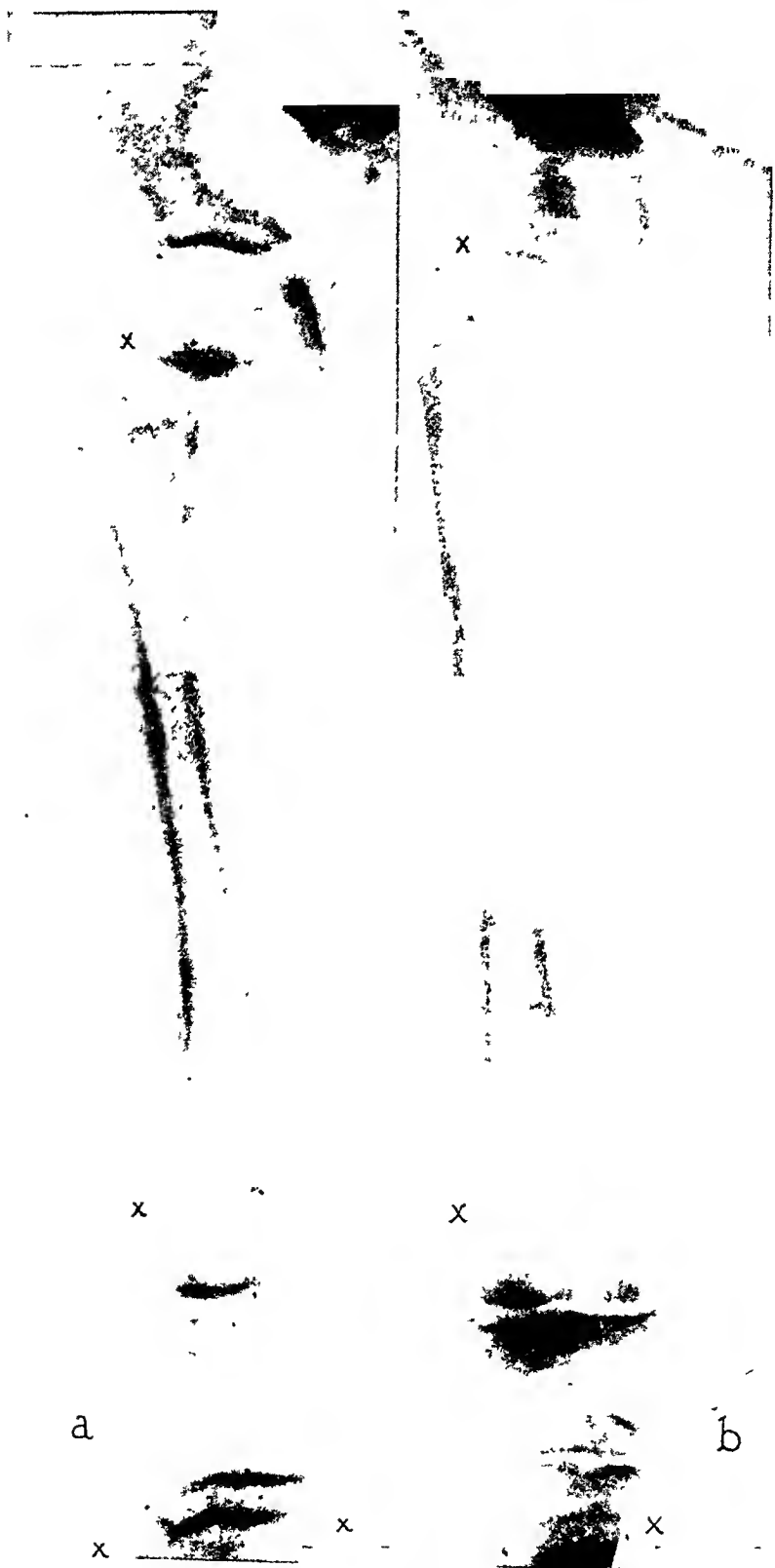


FIG. 1.—Proportions of growth at ends of femur as indicated by heavy bands (x) from (a) about one year of phosphorus medication in a four-year-old child, and (b) a period of malnutrition in a seven-year-old child.

than in those of the rest of the body, as estimated by comparing sitting height with lower extremity length. Then follows a progressive retardation of growth until bony fusion of epiphyses and diaphyses is accomplished.

The fundamental cause of skeletal growth as with the growth of all tissues lies buried in a heap of biologic reactions as yet very little understood. It is known that much is inherited in the germ plasm and usually can be altered but little. It is also known that mechanical forces, as those resulting from muscular action and gravity have an important influence on bone growth. In addition there are the specific chemical forces that are active in the endocrines and the nutriments as well as in various acquired disorders that influence skeletal growth. In a given case it is often difficult or impossible to evaluate the part played by one or more of these factors in control of growth. An example of bone growth determined by factors in the germ plasm and little influenced by external forces is seen in a case reported by L. Keck.⁴ A child, one month old, had a congenital bifurcation of the leg, the tibia, covered by skin and subcutaneous tissue being in one compartment, and the fibula and foot with all the muscles in the other. Despite the absence of muscular action on the tibia its size and shape approached fairly near to the normal. While the tibial growth was not greatly retarded by the absence of the play of static-cinematic forces upon it, the fibula was definitely stimulated by them as shown by transverse growth hypertrophy especially in its lower half.

Fell and Robison⁵ have made significant observations of inherent growth tendencies in the skeletal anlagen. They studied the growth of five and one-half to six-day-old embryonic chick femurs *in vitro* by explantation into plasma and embryo extract for periods varying from three to 27 days. The five and one-half-day-old femurs were short thick rods of cartilage with rounded processes representing head and trochanter proximally and condyles distally. There was a rapid increase in length of shaft and in diameter of the epiphyses with approximation of the normal shape of the femur despite the fact that there was no play of forces exerted by soft parts upon the explant. Ossification occurred along the surface of the middle portion of the shaft of some of the oldest specimens. Thus, a markedly inherent capacity of the embryonal femur for both growth and differentiation was displayed. C. B. Huggins, J. Exp. Med., has quite recently observed similar continued growth of the vertebrae of the tail of the young rat when they are transplanted free in its abdominal cavity.

In general it appears that longitudinal growth of the bones of the endoskeleton through cartilage is less influenced by the removal of mechanical stimuli than is transverse growth through fibrous tissue. Thus, in case of marked loss of function of limb from infantile paralysis or ankylosis from Still's type of chronic arthritis, the shafts may continue to increase in length and the epiphyses to enlarge at a rate that is only moderately under normal, while at the same time the transverse growth of the shafts may be much retarded or even arrested. This is illustrated by a roentgenogram of the knee region of a 12-year-old girl with Still's disease of several years' duration

(Fig. 2). In this case retardation of growth was also complicated by atrophy of disuse in which there was concentric absorption of bone along the periosteal surface of shaft which actually reduced the diameters of the bones, especially the fibulae. The bony centers in the growing epiphyses having over their sides a surface covering of cartilage the cells of which do not become phagocytic



FIG. 2.—Retardation of transverse growth and concentric atrophy of disuse of shafts in Still's arthritis in 12-year-old girl. Epiphyses not reduced in size. Note the large epiphysis in contrast to the narrow shafts which were only slightly shorter than normal.

during periods of disuse are not subject to concentric atrophy and consequently never decrease in diameter.

Osborne and Mendel,⁶ and Winters, Smith and Mendel⁷ found that rats have a growth potential that may be slowed up during the period of restriction of certain foods or inorganic salts, but after restoration of an adequate diet the loss is soon made up. However, the skeleton is not retarded in longitudinal

growth by the dietary deficiency. But one difference between rat and man is that the epiphysial lines remain open and longitudinal growth continues throughout the life of the rat, whereas they close in man between the 12th and 22nd years, according to the epiphysis concerned. And it is known that while prolonged nutritional deficiencies as of vitamin D during the growing period of man usually produce only temporary retardation, they may result in an undersized mature skeleton, as witnessed in the case of rachitic dwarfism.

Endocrines and Bone Growth.—Of the glands of internal secretion, the hypophysis, the gonads, the thyroid and the parathyroids are the ones that are known to influence skeletal growth, in some cases directly, in others indirectly.

The secretion of the anterior lobe of the hypophysis augments bone growth. Overfunction in man causes gigantism and delayed closure of epiphysial lines, provided it begins before normal growth is complete and acromegaly provided it begins afterward. This view is supported by animal experimentation. Anterior lobe extract injected into the rat whose epiphysial lines never close, produces gigantism (Evans and Long⁸), while in adult dogs it produces acromegaly (Putnam⁹). Also it is found that tumors destroying the anterior lobe of the hypophysis and beginning before closure of the epiphysial lines cause delayed closure and pituitary dwarfism. Hypophysectomy in young animals causes dwarfism, the retardation of growth of the bones and testis being more marked than that of the other tissues. Feeding such animals anterior lobe extract causes them to grow, indicating that the growth stimulating hormone is formed there (P. E. Smith¹⁰). It is assumed that the eosinophilic cell secretes the growth promoting principle because pituitary gigantism and acromegaly are nearly always produced by an eosinophilic adenoma.

The effect of the gonads on bone growth is less well known. Castration and congenital or acquired hypofunction of gonads delay the time of closure of the epiphysial lines sometimes for a great many years which establishes the possibility of longitudinal growth beyond the usual span. In some cases it seems to continue and mild degrees of gigantism may result as in case of some of the "Skopzen" (members of a Russian religious sect practicing castration) studied by Tandler and Gross.¹¹ But in the great majority of cases there appears to be no further growth and height does not exceed that of the average adult.

Growth retardation with delayed puberty may occur in case of prolonged infectious disease during childhood and adolescence. It is seen especially in severe tuberculosis of the spine or hip. Three such male patients have recently been observed in our orthopedics clinic in which at the ages of 17 to 20 the skeletal and testicular development was approximately that of 12 to 14 years. It is problematical as to how the infection delays growth, but it may be by depressing the hypophysis, which secondarily affects the bones and testicles. One patient came to autopsy at the age of 20, at which time the epiphysial lines were open and the testicles which were small showed no spermatogonia.

genesis. Fig. 3 shows him at the age of 17 years and Fig. 4 the delayed bone growth at 19 years.

Hypofunction of the thyroid gland as seen in cretins results in dwarfism during the normal period of bone growth and in persistence of the open epiphysial lines sometimes to well past middle life. Slight longitudinal growth may continue during adult life, but it never makes up the deficiency. Excision



FIG. 3.—Delayed puberty and retarded bone growth in 17-year-old boy with long standing tuberculosis of spine.

of the thyroid in young animals as rabbits not only dwarfs the skeleton but makes it porotic or pseudorachitic.

Evans¹² believes that the thyroid secretion probably affects bone growth only indirectly by its action on the anterior lobe of the hypophysis. Thyroid subnormality depresses pituitary function, *i.e.*, the thyrotropic pituitary hormone resulting in cretinic dwarfism. Smith¹³ found that the growth stimula-

tion which resulted when rats from which hypophysis, thyroid and parathyroids had been removed were injected with anterior pituitary growth hormone was increased if thyroid extracts were also administered.

Bone growth during hyperfunction of the thyroid (thyrotoxicosis) has not been studied in children, except for relatively short periods and almost entirely after the tenth year. Aub and co-workers¹⁴ have observed osteoporosis with increased excretion of calcium and probably of phosphorus in adults but there is little evidence that permanent underdevelopment of the skeleton results from juvenile thyrotoxicosis. The effect of prolonged overfeeding of thyroid to young animals has not been accurately determined. According to DaCosta and Carlson¹⁵ large doses usually produce a diarrhea, emaciation and death in a relatively short time. But the feeding of small doses to rats beginnings at the 18th to the 21st day and continuing for as long as 100 days produced no apparent change in size of the animals.

Chronic parathyroid deficiency following goiter operations with removal of parathyroid tissue has not been reported in children, but in adults it has not resulted in changes in the bones. Dr. L. R. Dragstedt has recently found that the bones of a young dog subjected to thyroparathyroidectomy followed by thyroid administration, continued to grow normally until killed after eight months despite the fact that the blood calcium ranged steadily between five and one-half and six and one-half mg. and the phosphorus between five and six mg. per 100 cc. Hammet,¹⁶ however, found slight retardation of growth of bone in rats after parathyroidectomy. On the other hand a continued excess of parathormone in the blood, whether from injection in animals (Bodansky,¹⁷ John-

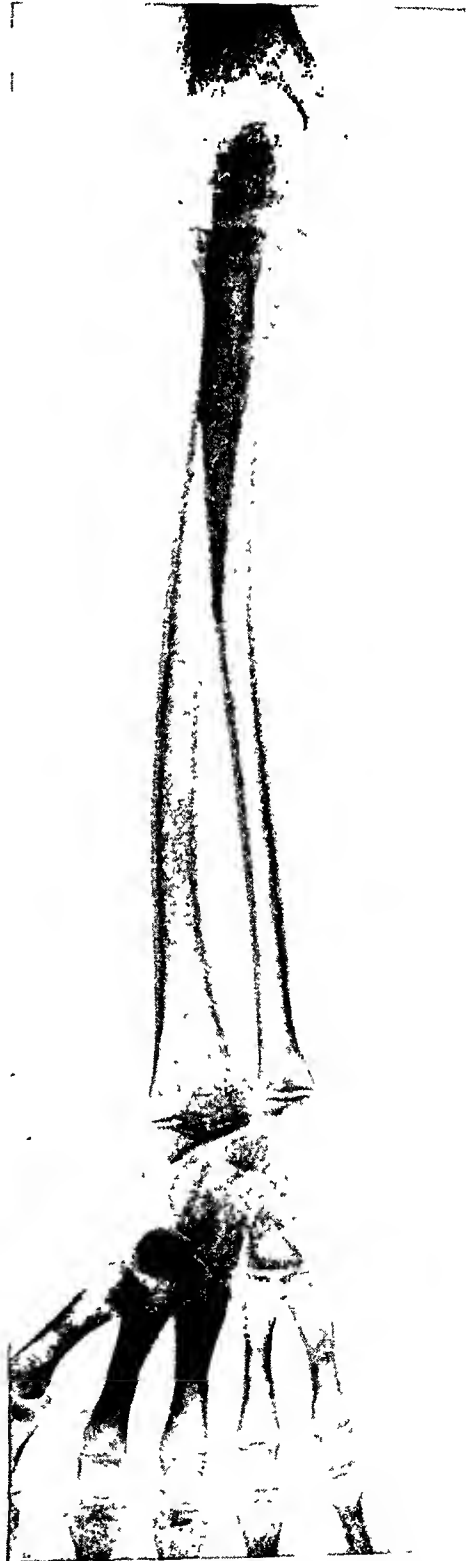


FIG. 4.—Roentgenogram showing delayed bone growth of patient in Fig. 3 at age of 19 years.

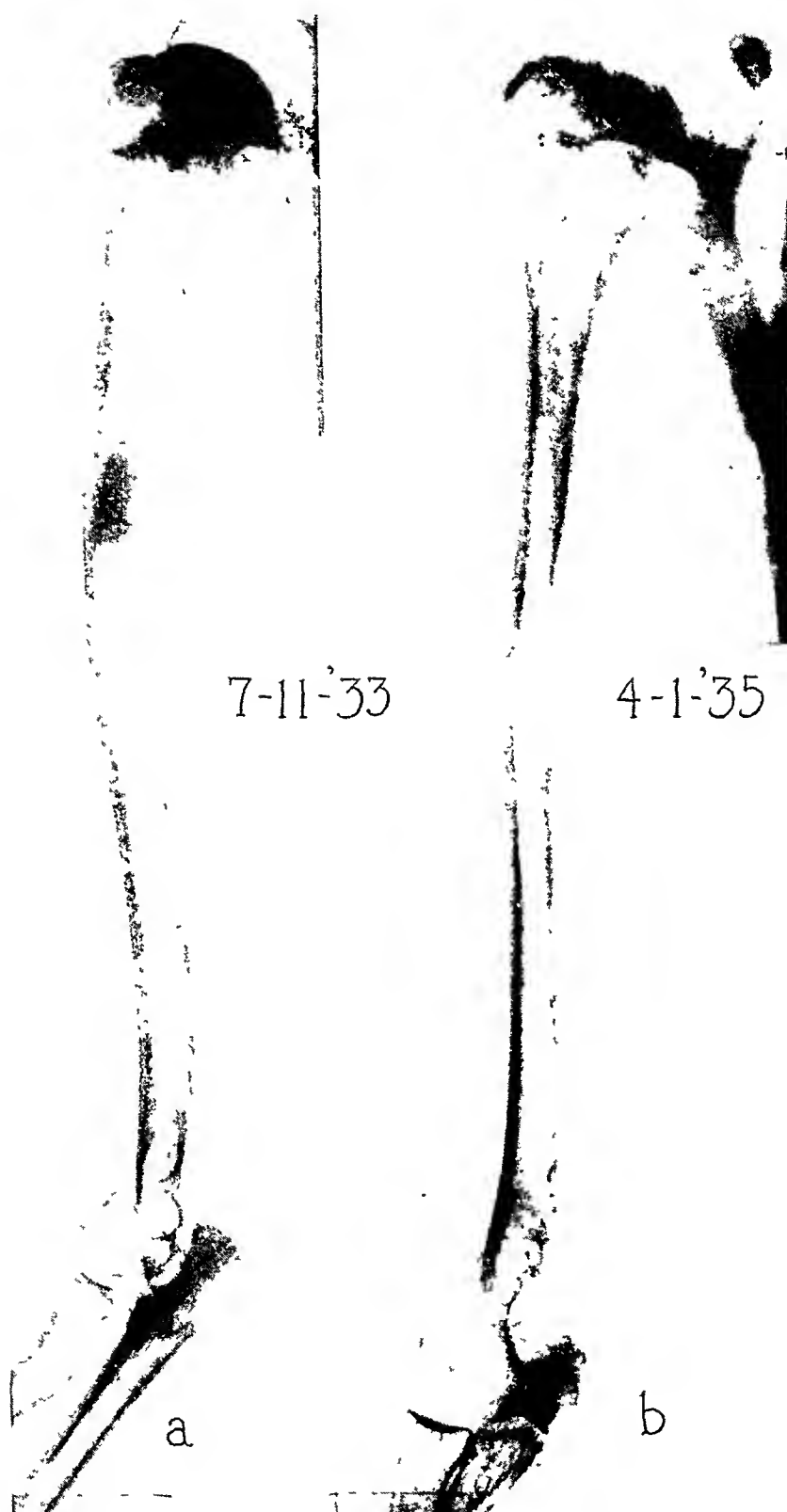


FIG 5.—Hyperparathyroidism. (a) Shows humerus at age of 11 years and four months; (b) at 13 years. There has been increase in length of shaft and in diameter of epiphyses during the interval but reduction in diameter of shaft.

son and Wilder¹⁸) or from parathyroid tumor results in withdrawal of calcium salts from the bones and hypercalcemia. In the seven reported cases of parathyroid tumors with hyperparathyroidism in children there has been little said about bone growth but osteoporosis has been a constant finding, cysts and giant cell tumors being absent. I have recently observed a case on the pediatrics service of the University of Chicago Clinics in which there was withdrawal of calcium from the bones, but despite this there was continuous, although atypical growth of the skeleton. A 13-year-old girl gave a history compatible with parathyroid tumor of about three years' duration. Two and one-half years before admission this diagnosis had been made elsewhere and one and one-half years before she had been examined in this clinic. The blood then contained $16\frac{1}{2}$ mg. of calcium and 2.5 mg. of phosphorus, per 100 cc. and roentgenograms showed osteoporosis with little relative change in dimensions of the bones. There was evidence of a healed fracture of the right humerus which occurred one year before. On readmission the blood calcium was 16.9 mg. and phosphorus 2.4 mg. per 100 cc. Fresh roentgenograms showed marked generalized osteoporosis with actual reduction in diameter of the shaft of the right humerus whose neighboring shoulder joint was restricted in motion by calcium deposits about it (Figs. 3, 4 and 5). The shafts of the other long bones were approximately of the same diameter as in the previous roentgenograms. On the other hand, all bones had increased in length and the bony centers of the epiphyses were considerably increased in diameter. This shows that despite the presence of osteoporosis, enchondral bone growth went on in the epiphyses and at the ends of the shafts, yet transverse growth of shaft by fibrous ossification was practically suspended.

The sympathetic nerves appear to play no special rôle in bone growth. Cannon and co-workers¹⁹ observed unaltered growth after total excision of the sympathetic chain on either one or both sides in young cats. Bisgard²⁰ observed no difference in the hind limbs of growing goats after unilateral excision of the lumbar ganglia and no acceleration of growth from the same procedure carried out on the paralyzed side of a monkey with experimental poliomyelitis. On the other hand Harris²¹ reported increased longitudinal growth after lumbar sympathectomy in cases of retarded growth in one leg from poliomyelitis. But muscle regeneration might play a rôle in such cases.

Plasticity of Growing Bone.—A substance as hard as bone is naturally thought of as possessing a considerable degree of stability. But physiologic hardness and biologic plasticity are attributes that do not run counter to each other. In fact, a growing bone is in a constant state of structural change which concerns the metaphyses most and the cortex in decreasing amounts away from the ends. The ends of the shafts increase in length and at a much slower rate in diameter by the laying down of bone in the epiphysal line. This is followed by a reduction in diameter of the shaft and an increase in thickness of the cortex at a decelerating rate away from the epiphysis; also, by a continuous realignment of trabeculae in the cancellous bone of the ends of

the shaft and to a much less extent in the epiphyses. Narrowing of the diameter of the ends of the shaft is accomplished by absorption of bone along the periosteal surface by mononuclear and polynuclear cells, while new bone is being laid down along the medullary surface by the process of fibrous ossification. Within, old trabeculae are being absorbed and new ones continuously formed to meet the shifting lines of force. The haversian, circumferential and interstitial systems of lamellated bone are constantly being added to as the shaft increases in length and thickness. There is more or less creeping replacement of old living bone by new bone as form and function change with growth, much as in the case of replacement of dead bone by new bone to be discussed later. The seat of greatest osteogenic activity in transverse growth of shaft between the metaphyses is along the periosteal surface. This plastic process gradually comes to an end as maturity is reached and is finally replaced by the slow balanced process of tearing down and building up which is concerned with the normal metabolism of adult bone.

Bone Repair.—Bone repair in its broadest sense includes the healing of either a general or a local impairment of the skeleton regardless of the causative agent. While the subject of general repair is one of great importance in the wider aspects of medicine and biology it is the narrower implications of local repair that are of special interest to the surgeon. Local damage of bone may vary much in cause and severity and the reparative response may vary accordingly. Thus, accidental trauma, operation, inflammation and neoplasm all produce their own types of lesions, and the healing reaction of each shows the special imprints of the causative factor.

Bone repair is seen in its simplest form as the reaction to uncomplicated injury to which this discussion will be limited. As it occurs in nature this is nearly always a fracture. In the repair of a fracture, nature's problem is to restore bony structure in such a way that normal function may be resumed. The trauma fractures the bone, tears or strips periosteum, produces a hematoma and damages ends of fragments sufficient to kill osteocytes for a variable distance back from the fracture line. Function is interrupted because of pain and loss of mechanical support. The tissue fluids of the injured region also undergo biochemical changes. These alterations in structure, function and chemical composition are followed by a reparative reaction, the morphologic aspects of which are better known than the physiologic. They consist essentially in the formation of a callus which eventually becomes bone and in the removal of the tissues that undergo necrosis. The unossified tissues that are active in the normal growth of bone especially periosteum and fibrous tissue of the marrow canal are thrown into much greater activity in the process of repair. In addition to these fixed tissue cells there are wandering and infiltrative cells, the lymphocytes, monocytes and macrophages, that are sufficiently metaplastic to take part in the formation of the callus. The first tissue formed invades the blood clot and consists of cells that morphologically are indistinguishable from the fibroblasts seen in the repair of other wounds. Harvey²² is of the opinion that fibroplasia is the first step in the repair of all tissues

derived from the mesenchyme. Various factors have been held to initiate this reaction. A biophysical one is the disturbance in the static equilibrium of the cell with its environment by the trauma causing it to revert to the spherical form which gives the most efficient ratio of cytoplasm to surface area. This disturbs the ratio of cytoplasm to nucleus and sets up cell division, thus restoring the balance.

Carrell and Baker²³ attribute growth of these primitive cells in tissue culture to chemical agents in the media formed by the break down of damaged cells by autolysis. They are the higher split products of certain proteins, which, when partly digested, caused marked acceleration of growth when added to tissue cultures. The higher split products of fibrin were especially active. This raises the old question of the possible stimulating action of the fibrin in the blood clot of the fracture on the callus (Potts²⁴). Since there is necrosis of bone in the fragment ends for a variable distance back the question arises if growth stimulating substances are formed by autolysis of its proteins which help to bring about creeping replacement of the dead bone by new bone. Since the work of Gudernatch²⁵ has shown that certain amino acids as arginine and cystine stimulate growth when fed to tadpoles and others more complex as tyrosine, histidine, and diodo tyrosine, which is closely related to thyroxine, stimulate differentiation, the view is strengthened that products are liberated in the hydrolysis of proteins of the dead tissue which stimulate callus formation.

Subsequent changes in this fibrous callus vary according to whether it is periosteal or endosteal in location. In any case it is sufficiently embryonic to undergo extensive metaplasia as emphasized by Downs and McKeown.²⁶ If endosteal it is gradually transformed into cancellous bone by direct or fibrous ossification, cartilage never appearing in the process. If periosteal it goes through a much more complex process of metamorphosis as it changes into bone. There is partially reversion to the enchondral process of bone formation somewhat similar to that of longitudinal growth and partially fibrous ossification. As the callus grows its peripheral portion consists of young proliferating fibrous tissue usually covered by the thickened outer layer of periosteum. Beneath this there is formed, after six to ten days, a layer of hyaline cartilage which increases in thickness toward the end of each fragment and forms the bulk of the peripheral intermediary callus. Along the surface of the cortex of fragment end new bone begins to form in four to six days and ossification extends peripherally, gradually converting the cartilaginous callus into a bony one as the fibrous callus is converted into a cartilaginous one. The ossification of the cartilaginous callus in the thickest part of the periosteal portion and in the intermediary portion is by enchondral bone formation similar to that seen in the epiphysial line, but with much shorter columns of cartilage and with faintness or absence of the zone of calcification. But the ossification of some of the cartilage, particularly in its thinner portions away from the fracture line, is by direct change of young cartilage cells into osteocytes, as pointed out by Zondek.²⁷ Other portions, especially at the limits of the callus, ossify only by fibrous bone formation.



FIG. 6.—Peripheral callus of 17-day-old fracture showing enchondral ossification (a), fibrous ossification (b), and superficial fibrous callus (c).

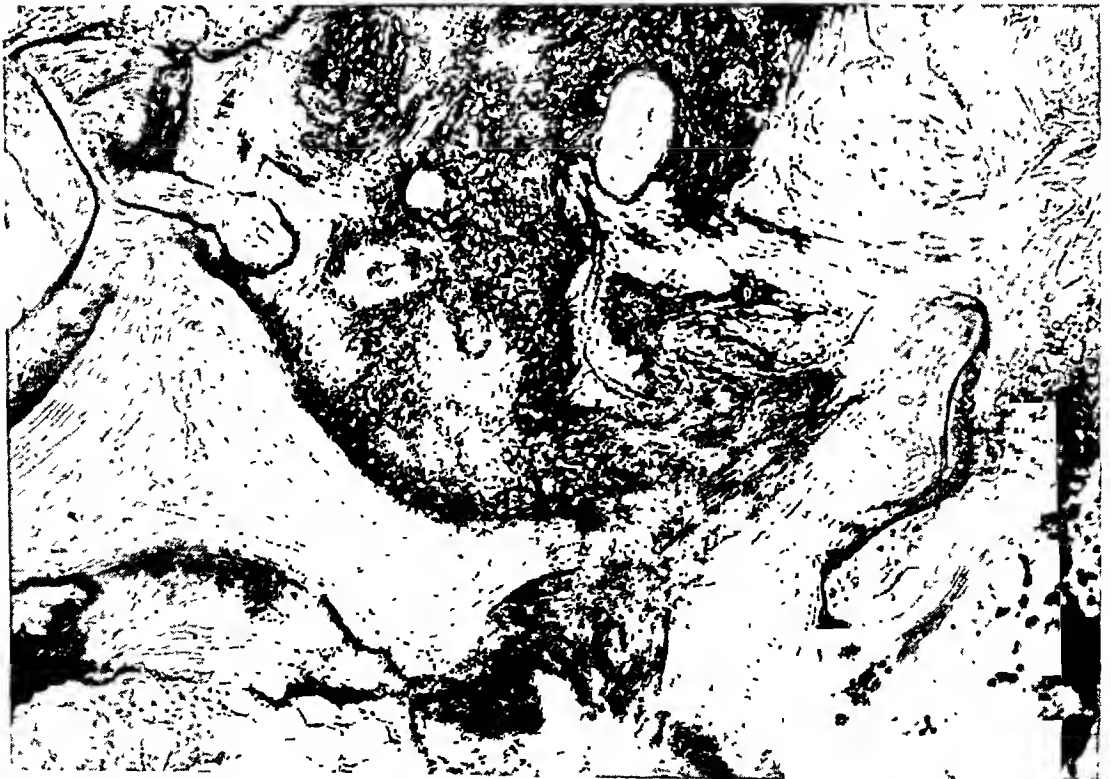


FIG. 7.—Calcification and metaplasia of mature fibrous tissue into bone in fragment end of ununited fracture of four years' duration.

Figure 6 is of a 17-day-old peripheral callus from a fractured ulna of a man. It shows both fibrous and enchondral ossification occurring in neighboring regions.

The peripheral bony callus becomes dense in its superficial portion and spongy in its deeper portion and old cortex may be partly absorbed as callus condenses and diminishes in size. The intermediary callus is always the last to ossify and failure results in delayed or non-union. The initial fibrous callus is very plastic in its later differentiation. It gives rise not only to cartilaginous and bony callus but also to fatty and hemopoietic bone marrow. Old fibrous callus that has organized into mature fibrous tissue may, under appropriate stimulation, slowly ossify by calcification and gradual metaplasia into bony elements (Fig. 7). This is similar to the metaplasia sometimes seen in tendinous or ligamentous ossification.

The breaking strength of the bone, demonstrated experimentally by McKeown, Lindsay, Harvey and Howes,²⁸ is restored to normal in somewhat less than double the time of completion of ossification of the callus and before it is fully transformed into compact bone.

The compact bone that dies in the ends of the fragments is gradually invaded by blood vessels and osteogenetic tissue from the contiguous living cortex and replaced by new bone by the process of creeping substitution as shown in Fig. 8, which is of a fragment end resected because of non-union of the femur 137 days after fracture. New blood vessels and fibrous tissue invade the canals. The dead bone is absorbed by mononuclear and occasional polynuclear osteoclasts and replaced by fibrous tissue, marrow and vessels. After the absorption has advanced to a certain point a stimulus for ossification comes into play and new bone is deposited on parts of the walls of the dilated canals in successive layers or rings while absorption is continuing in other regions. Weakening of the dead supporting structure beyond a certain point may cause metaplasia of osteoclastic cells into osteoblasts. In some regions it is a question if the new bone deposited on the old does not then proliferate and destroy and directly replace the old; that is, it is also osteoclastic. The changes are similar to those which take place in the transformation of the dead cortex of a bone transplant. The lime salts of the dead bone undergoing creeping replacement may be to some extent redeposited in the replacement bone. If so, it is very limited as the great mass of lamellae are deposited concentrically away from the old bone and in the field about the blood vessels. The amount of necrosis occurring in the ordinary case does not seem to interfere with bony healing. In fact, the necrotic bone has been regarded by some authors, as Lexer,²⁹ as a stimulus to bone formation. Hemopoietic and fatty marrow always form by metaplasia at the same time that new bone is laid down.

In case of fracture of bones bordering extensively on joints, as the neck of the femur, the carpal navicular and the astragalus, the blood supply to an entire fragment may be cut off. In that event it will undergo necrosis in mass. An analysis of a series of cases of intracapsular fracture of the neck

of the femur (Phemister³⁰) has shown that this occurrence greatly predisposes to non-union of the fracture. Thus, in 49 cases there was death of the head in 32 cases with non-union in 28 of them, while in the 17 cases in which the head remained alive, there was non-union in only nine. The dead fragment, in the event either of union or non-union, is gradually invaded by blood vessels and embryonic connective tissue. A process of creeping substitution of the dead bone by new bone is then set up, which, after several months or years, may terminate in complete replacement by new bone. Fig. 9 shows a bisected necrotic head which was excised four and one-half years after fracture because of non-union. Its white central portion consists of



FIG. 8.—Necrotic cortex (x) of end of fragment of a 137-day-old ununited fracture. Absorption by mononuclear and polynuclear osteoclasts (a) has gone on and new bone (b) has been deposited in parts of the dilated canals.

dead bone and marrow, but its grayish periphery consists of living bone which has gradually replaced dead bone. Fig. 10 is a microscopic section at the junction of the dead and living portions showing the fibrous zone of transformation. However, if the fracture unites and the dead bone is subjected to much weight bearing during this period it may collapse at the point of greatest pressure, which occurrence not only interferes with the process of creeping replacement, but also greatly deforms the articular surface.

When bone is transplanted or when a splinter is completely detached, in case of fracture, practically all of its osteocytes die. But, if it is placed in line of bony support, its surviving unossified fibrous elements in its canals and along the surfaces usually produce new bone which helps to unite it to the adjacent bone and to replace the dead bone.

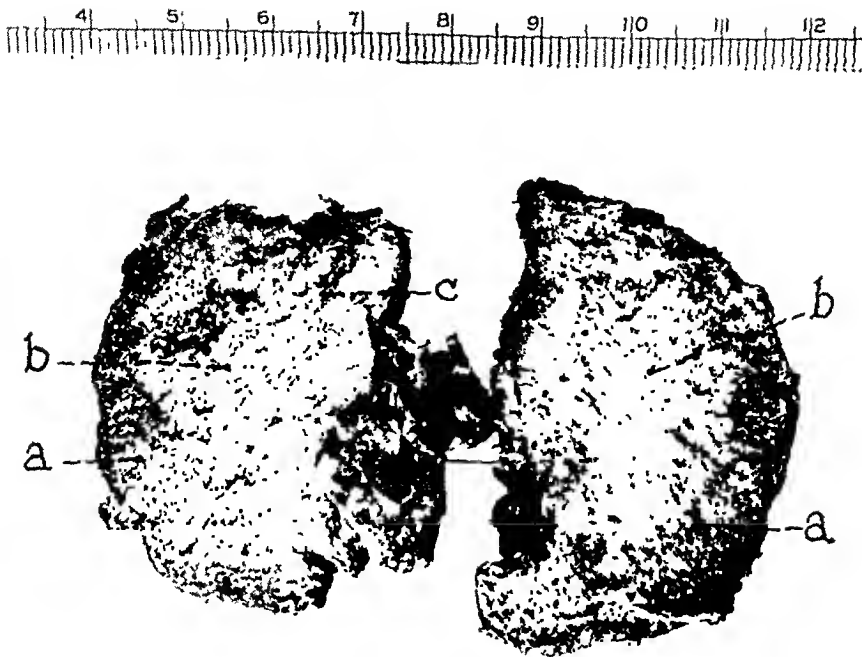


FIG. 9.—Bisected dead head of femur in case of non-union of neck fracture. Grayish peripheral portion replaced by new bone (*a*); white central portion dead and unchanged (*b*); zone of transformation (*c*).

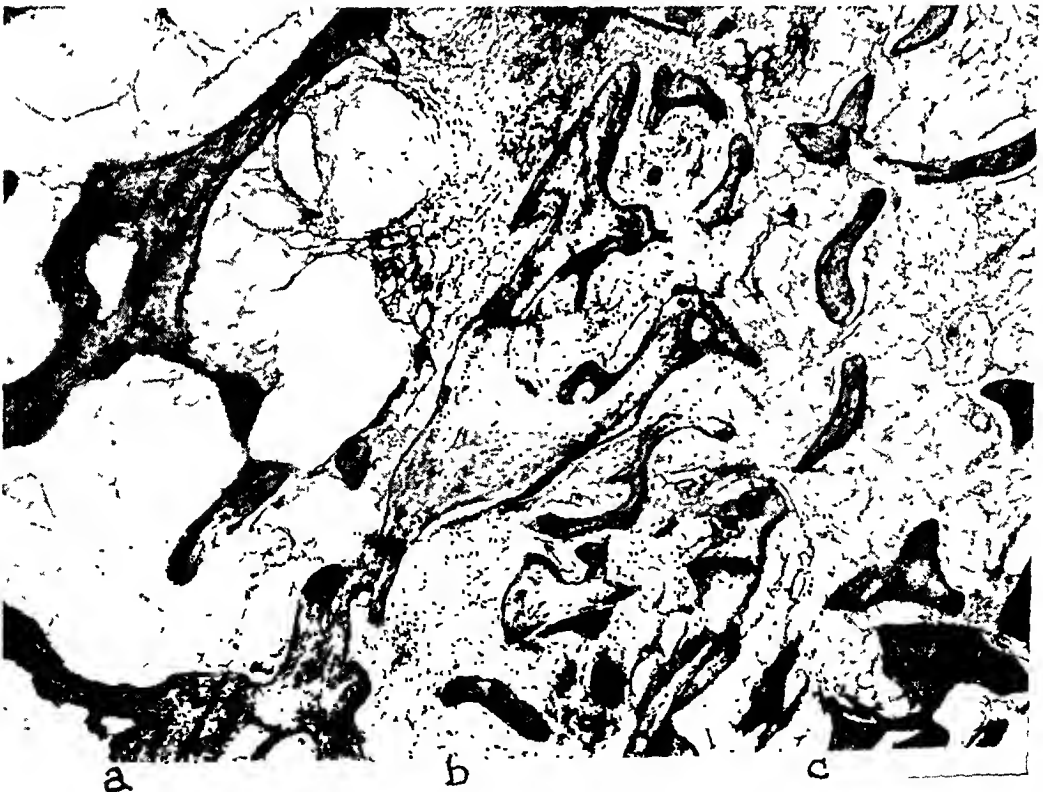


FIG. 10.—Photomicrograph taken through junction of dead and living portions at (*c*) Fig. 9. (*a*) Shows central dead bone, (*b*) the zone of transformation, and (*c*) the new replacement bone.

The debated question as to the rôle of the periosteum in fracture healing is one that should not go without mention, much as one might wish to avoid it. There can be little doubt from both clinical and experimental evidence that the less the periosteum is disturbed the more quickly and surely the fracture heals. It has been my experience that open reduction and stripping of periosteum with or without fixation of fragments by means of any material except an autogenous bone graft is followed by delayed or non-union oftener than when a corresponding degree of reduction and external fixation are obtained by the closed method. Experimentally excision of periosteum from the fragment ends delays callus formation and ossification (Haldeman³¹). These facts indicate that the connective tissue outside of bone and periosteum does not function as efficiently as the periosteum in the process of healing of a fracture.

The same is true in the healing of experimental bone defects (Phemister³²). Subperiosteal resection of bone in young animals is followed as a rule by moderate to complete restoration of the missing segment, especially when there is a splint bone present to maintain position and fixation. Subperiosteal resection in adult animals is followed by some regeneration, but it is usually very incomplete. On the other hand, resection of an entire segment of a bone with its periosteum at any age results in failure of regeneration. These same conditions apply roughly in man when resections are performed because of the presence of disease, although severe infection, as osteomyelitis in the field of subperiosteal resection by killing osteogenetic cells may restrict the amount of regeneration. In the sloping removal of large areas of the shaft in the treatment of chronic osteomyelitis—the so-called saucerization operation—the stripped off periosteum sometimes forms a layer of new bone in children and young adults that soon fills out most of the defect, thereby defeating the purpose of the operation which was to have it filled by the soft parts. Painting the inner surface of periosteum with a caustic chemical, as formalin or Zenker's fluid, reduces or destroys its osteogenic power, as shown by Van Allen,³³ following rib resection in thoracoplasty.

In segments of the extremity that possess two bones, retardation or failure of regeneration of one that is damaged will set up a compensatory transverse enlargement of its healthy associate. The process is one of very rapid growth initiated to restore function and it continues until a balance is established between capacity of muscles to act and bones to support.

In reverse manner, bone placed out of line as a result of healing of a fracture in malposition, so that its function is diminished or completely suspended undergoes retrogressive changes. Thus, a long projection of a fracture into soft parts may be completely absorbed in the course of time. Detached bone displaced into the soft parts at first usually proliferates along its periosteal and endosteal surfaces and a fracture through such a displaced piece may heal. But after this initial repair the bone undergoes attrition and slowly decreases in size, sometimes to the point of total disappearance. Thus (Phemister³⁴) a large fragment of cortex of fractured tibia was dis-

placed posteriorly in the soft parts. The fracture healed and function was restored to normal but a roentgenogram taken six years later revealed almost complete disappearance of the fragment in the soft parts.

Venous stasis produced by ligation of the femoral vein slightly hastens the healing of fractures and regeneration of excised short segments of the fibula, as shown by Pearse and Morton.³⁵ Sympathectomy has practically no effect on the healing of a fracture, either when carried out at the time of fracturing, or, as McMaster and Roome³⁶ showed, when the bone is fractured as late as eight months after the sympathectomy. Administration of ductless gland hormones has not been definitely shown to have any effect on the healing of fractures, whether the healing is normal or delayed, except parathormone, which delays healing. Fractures in neglected hyperparathyroidism or von Recklinghausen's disease are predisposed to non-union. On the other hand, parathyroidectomy (resulting in hypocalcemia) has been shown also to delay bone repair by Erdheim,³⁷ Ross³⁸ and Speed, Rider.³⁹ But it has not been shown, either by animal experiment or clinical observation, that deficiency of the other endocrine secretions influences fracture healing. Calcium or phosphorus administration has not been definitely shown to hasten the healing of fractures. However, Brunschwig⁴⁰ has administered calcium gluconate to six patients with multiple osteoclastic carcinoma metastases and in two instances marked bone formation in the carcinomatous regions has occurred similar to that sometimes seen following roentgen ray treatment. On the other hand, diets deficient in calcium only have been shown by Downs and McKeown,⁴¹ and McKeown, Harvey and Lumsden⁴² to retard fracture healing to a very slight extent. Kernwein, in our laboratory, has studied fracture healing in fasting rabbits receiving only physiologic salt solution. A fibrous callus formed in normal time but there was slight retardation of conversion into bony callus in animals living 25 to 34 days, at which time the controls showed high grade to complete ossification.

Vitamin D has been found by several observers, as Fisher and Key,⁴³ not to hasten the healing of fractures in normal persons on normal diets, and not to prevent atrophy of disuse accompanying a fracture. And it is well known that fractures in rachitic and osteomalacic patients usually heal in about normal time. There is some disposition to delayed and non-union in cases of osteogenesis imperfecta, but, in general, local bone repair shows a high degree of independence of general body reactions.

Nature of Ossification.—We now come to a discussion of the nature of the process of ossification which is the same in both growth and repair. In the formation of bone there are three essential elements to take into consideration: the cells, the organic matrix, and the lime salts. The oldest and most widely accepted theory of ossification since the establishment of microscopic anatomy is that it comes about somehow as a result of the activity of cells. Certain cellular components of the bone or of membrane which precedes it, as a result of qualities, either inherent or acquired, through the circumstances of their environment, lay down a matrix of collagen fibers

and cement which are chemically and morphologically similar to those of white fibrous connective tissue. Very soon they play a part in the deposition of lime salts in the matrix. Some of these cells become incorporated in the lime salts and mature into osteocytes. Others persist as such along the surface of the bone as do the cells in fish bone, none of which are incorporated in the matrix. Still other cells metamorphose into the components of bone marrow. In some instances as in the ossification of tendon or of the insertions of muscle or fascia to skeleton, there is a conversion into bone of mature fibrous connective tissue. And some observers, as Macewen⁴⁴ and Weidenreich,⁴⁵ maintain that in enchondral ossification the liberated cartilage cells take part in bone formation. Thus, the cell theory of ossification implies a high degree of specific activity which is either inherent in the cell or transmitted to it by an altered environment.

In contrast to this is the humoral theory of ossification recently propounded by Leriche and Policard⁴⁶ and sponsored by others, as Murray.⁴⁷ According to it no specific activity is necessary on the part of the cell. All connective tissues having a matrix of collagen fibers and cement serve the purpose equally well. No such claim has been made for elastic tissue or reticulum. The changes that bring about ossification are initiated in the tissue fluids of the matrix by extra cellular substances. They consist essentially in the creation of a local acidity and the establishment of an available local source of calcium salts. This combination results in supersaturation of the tissue fluid and precipitation of calcium salts in the matrix with the creation of bone. There is no discussion of the difference between calcification and ossification and of how the complex morphologic changes in ossification are brought about. In local bone repair, as the healing of fractures, the increased local acidity which, according to Stirling,⁴⁸ lasts about one week, is created by local tissue necrosis, the hematoma, and local circulatory stasis. The local source of available calcium is created by the local death of bone and the adsorption of calcium by the fibrin of the hematoma.

Against this humoral theory is the fact that some connective tissue cells possess greater osteogenic properties than others. The existence of a specialized osteoblast is proved by the occurrence of ossification of the metastases of osteogenic sarcomas in the soft parts, as the lungs, lymph nodes, and skin (Brunschwig⁴⁹). Fig. 11 is a roentgenogram and Fig. 12 a microscopic section of an ossifying metastasis in the skin of the face from an ossifying sarcoma of the upper end of the humerus. Extensively ossified metastases were also found in the lungs at autopsy (Bone Sarcoma Registry No. 335). The metastatic tumor cell possesses the osteogenetic property. No local tissue action could possibly account for this. In my opinion most of the ordinary growth and repair of bone is accomplished by cells within and immediately on the surface of bone that have more ossifying tendency than the connective tissue cells outside of bone. However, under circumstances of altered environment connective tissue cells that normally do not ossify may change in character, and become osteoblastic. And there is a dif-

ference in ability of different connective tissues to form bone in the same altered environment. Thus, Huggins⁵⁰ has shown that fascia can be made to ossify if it is placed in contact with proliferating urinary tract epithelium, whether the fascia is transplanted to the bladder, or the epithelium is transplanted to fascia or both fascia and epithelium are transplanted together into the spleen. On the other hand, Huggins showed that certain other connective tissues, as that within the spleen, which is largely reticulum or that of bladder wall which is largely white fibrous, do not ossify when in contact with proliferating bladder epithelium. Also a free transplant of fascia will not ossify when mixed with lime salts and placed into a fresh defect in bone, as shown by Key and by Stewart.⁵¹ This latter finding is strong evidence against the theory that any connective tissue will ossify if simply in a field with a low pH and an adequate local supply of calcium. Haldeman and Moore⁵² showed that a local excess of solid calcium salts implanted at a fracture site made practically no difference in fracture healing.

As to the low pH in the fracture field resulting from tissue damage it is admittedly present only while the fibrous callus is forming, *i. e.*, during the first week, so that another explanation would have to be found for holding the calcium locally during the important period of ossification which occurs later. And as to the damaged local bone being the source of the calcium that is deposited in the periosteal and endosteal callus, the idea appears far fetched, if one studies fracture healing microscopically or even in roentgenograms, because the amount of dead bone at the fragment ends is relatively small and the signs of absorption of it appear too slight to account for all of the calcium deposited in the callus.

However, in the process of creeping replacement of dead bone or a similar calcareous deposit by living bone, whether in a transplant, boiled bone, or calcified necrotic tissue, it is possible that the local supply of calcium is the source of that which is deposited in the new bone. Bone growth has not been explained by anyone by such changes as Leriche and Policard hold responsible for bone repair.

According to Cameron and Moorehouse⁵³ blood plasma and the tissue fluids each hold about the same amount of calcium which is present in both crystalloidal and colloidal solution, part of the calcium being ionized and part un-ionized. An important recent discovery is that calcium carbonate and tricalcium phosphate do not exist in bone as separate deposits, as was long supposed, but in chemical combination as a double salt $(\text{CaCO}_3)_X \text{Ca}_3(\text{PO}_4)_2$ in which X is usually 2. This substance as found in nature is known as dahlite. The discovery was made by roentgenographic spectral studies of bone by DeJong, Taylor and Sheard and Roseberry, Hastings and Morse.⁵⁴ There are no lines present in roentgenographic spectograms of bone which correspond to crystalline calcium carbonate and tricalcium phosphate has never been prepared in crystal form, according to Taylor and Sheard.⁵⁵

Hastings⁵⁶ has formulated the arrangements favorable for bone forma-

BONE GROWTH AND REPAIR

Fig. 11—Radiograph of ossified sarcoma metastasis in skin of face from osteogenic sarcoma of humerus

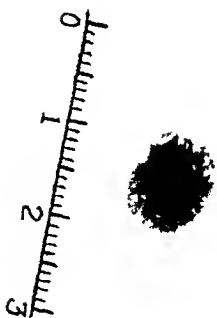
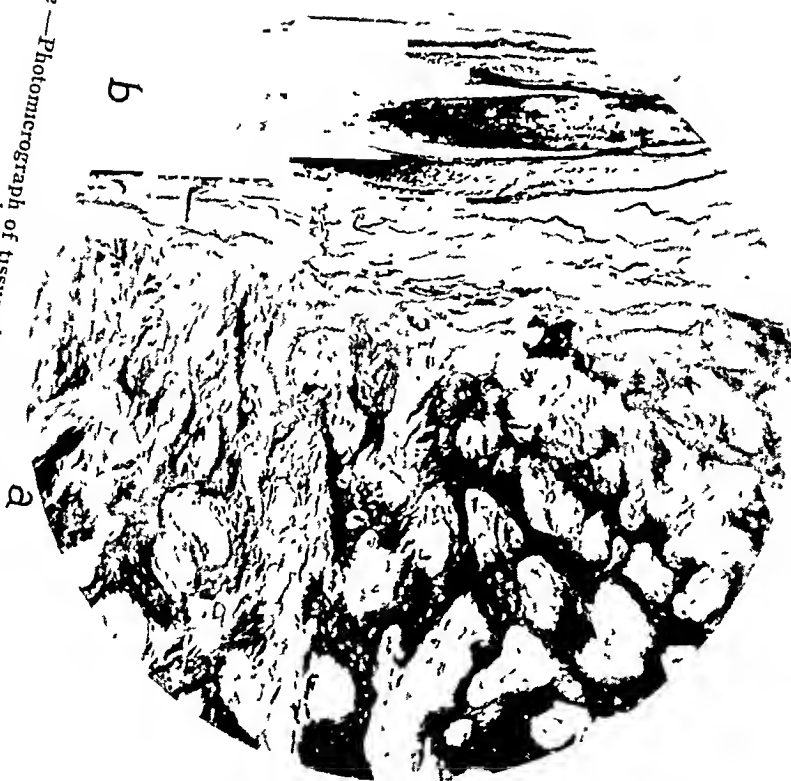


Fig. 12—Photomicrograph of tissue shown in Fig. 11. Tumor bone (a), about hair follicle (b).



tion as follows: (1) Optimum physical conditions for the surface precipitation of calcium salts on surfaces which are provided by newly formed fibrils and cement; and (2) optimum chemical conditions which are provided by the existence of calcium ions, phosphate ions and carbonate ions in the tissue fluid. In order to have precipitation of the double salt $\text{CaCO}_3 \cdot 2 \text{Ca}_3(\text{PO}_4)_2$ it is necessary that its solubility product constant be exceeded. This might be accomplished by an increase in the calcium, PO_4 or CO_3 ions. Then, by the law of mass action governing difficultly soluble salts, the calcium carbonate and the calcium phosphate will be precipitated together.

A difficult question is which of these ions is increased to such a point and how is the increase brought about? The theory of Robison⁵⁷ is that the phosphate ions are increased due to the splitting action of an enzyme, phosphatase, upon the esters of hexose phosphoric acid. Such esters are present in the blood and tissue fluids. Phosphatase has been demonstrated in the blood and in the fields of predilection for ossification, as epiphysial cartilage, periosteum and membrane which preforms bone. Taylor⁵⁸ thinks that osteoblasts of bone or connective tissue cells under continuous strain form phosphatase whereby bone is laid down around them. But phosphatase is also present in equal abundance in other tissues, which do not ossify or calcify, as, for example, the kidney. This militates against it as the cause of ossification. That phosphatase may be present in tissues for purposes other than to promote the precipitation of calcium salts has been suggested, but not yet established. Taylor thinks that in the kidney it is active in phosphate excretion. On the other hand, while less probably so, a local increase in number of carbonate ions could be responsible for the dahlite precipitation in bone and an enzyme (carbonase) might be the agent which brings it about.

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THE TREATMENT OF TUBERCULOSIS OF THE SPINE IN YOUNG CHILDREN

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THE surgical treatment of tuberculosis of the bones and joints was a natural step in evolution with the development of aseptic operative technic. The results of the early attempts to accomplish permanent cure of bone and joint tuberculosis by complete or partial excision were discouraging. These early operators were working under the false impression that they could eradicate the disease by such surgery and were not primarily interested in an improved method of splinting the joint involved. Such surgery was not successful and gave way to treatment by immobilization in plaster jackets and braces. Observations of large series of cases over long periods of time brought out two important facts. First, tuberculous joints without surgical interference show little tendency to heal (actually may persist, though relatively quiescent, for as long as 50 years) and, second, when nature effects a cure the joint is usually firmly ankylosed.

The modern approach to the treatment of bone and joint tuberculosis includes first of all a recognition of the need for rest of the body as a whole and in particular of the joint or joints diseased. No apparatus which has been used, and this includes the most accurately applied plaster jacket or brace, can give immobilization which is comparable to satisfactory fusion of tuberculous joints (Fig. 1).

The leading proponents of the treatment of tuberculosis of the spine by means of adequate immobilization through an arthrodesing operation have been Drs. Fred Albee and Russell A. Hibbs. Both of these surgeons have had an experience with this procedure over a period of more than 20 years. The patients have been accurately studied and follow up procedures have been carried out. In 1930 Albee¹ included in his review the report of 181 cases of children who were under ten years of age when operated upon. No detailed analysis of this particular group was made, but in the entire series of 865 cases operated upon, the result in 90 per cent was classified as excellent or good. Hibbs^{4, 5} reported the results of spine fusion by his method in 210 cases. Of this group 98 were ten years of age or under at the time of operation. The percentage of patients cured or markedly improved was approximately the same as that reported by Albee.

Although the excellent results reported by Hibbs and Albee did appear to justify the general adoption of this procedure, there have been many objections to operations upon children under 12 years of age. This study of the treatment of tuberculosis of the spine in young children was undertaken because of dissatisfaction throughout this country and in Europe with the results obtained by attempts at fusion of the immature spine.

In 1927, Kidner⁷ reported a series of 14 cases of children under 12 years of age, seven of whom were operated upon and seven treated exactly the same but without operative interference. He concluded that cases in which fusion was done required practically as long and careful after treatment as those without operation. His treatment covered a period of three to four years and consisted of Bradford frame and plaster jacket. Some of his cases were kept recumbent one and one-half years after operation.

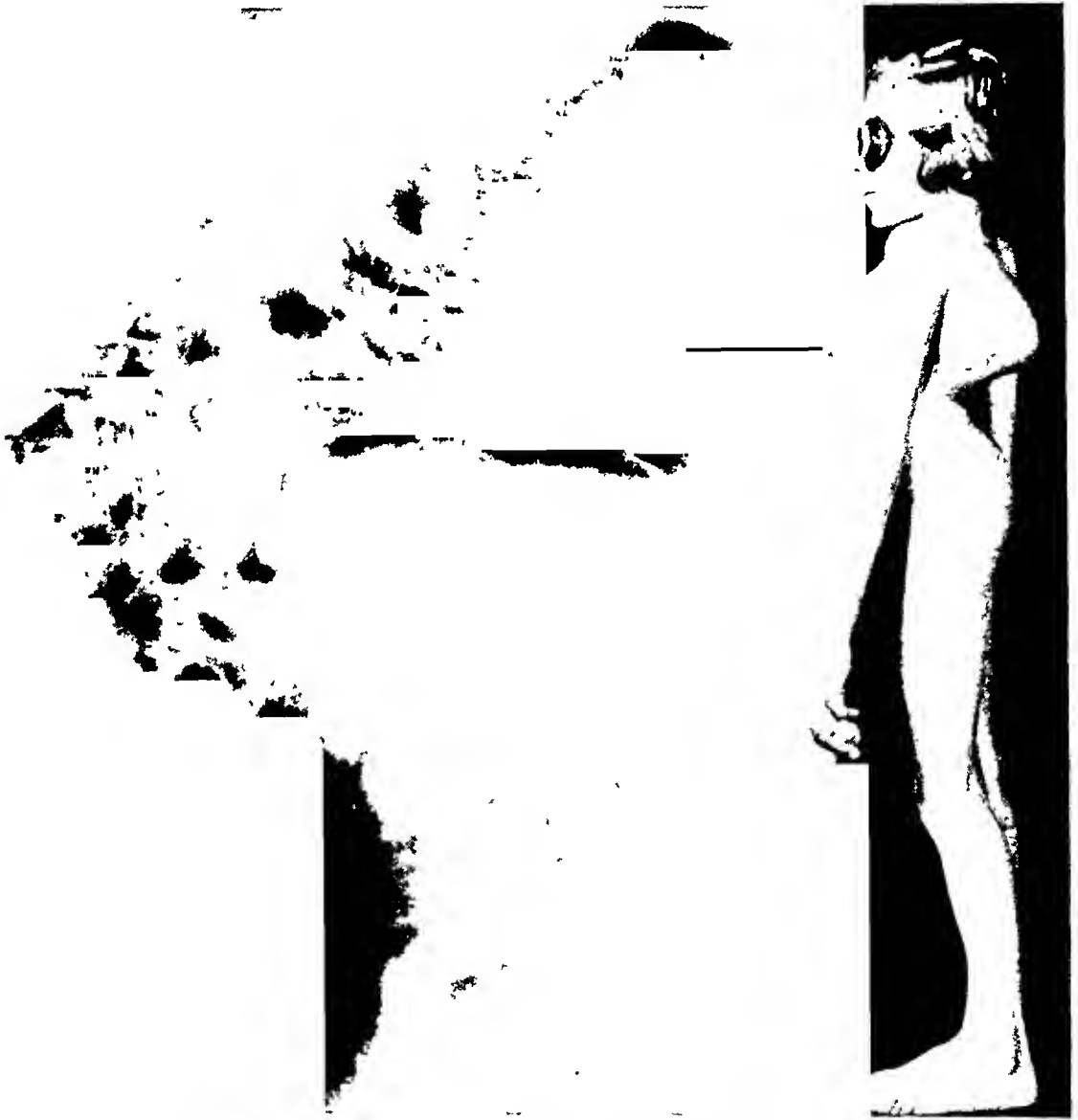


FIG. 1.—The result of "conservative treatment" for a period of 14 years. The spine has healed but, although the patient was treated in a sanatorium by means of plaster jackets and shells, this extreme angulation of the spine developed.

Allison^{2, 3} attempted to arthrodesis the spines of a group of young children several years ago but soon abandoned the procedure. Other operators using a technic copied after Hibbs or Albee have not been able to duplicate their results.

John L. Porter⁹ operated upon a series of ten spines using the Albee technic of a thick bone graft placed in a gutter made in the spinous processes. After six years he was unable to note more improvement than in a group of

unoperated spines. He admitted that his failure might be due to faulty technic.

Kleinberg,⁸ after five years in charge of 100 cases of joint tuberculosis in children, felt that a fusion should be done only if repeated flareups occur after three or four years of conservative treatment. In 1920 the Commission of the American Orthopaedic Association reviewed the subject and arrived at much the same conclusion.

FEASIBILITY OF SPINE FUSION BEFORE PUBERTY

One objection to attempts to fuse, and explanation of failure to produce a satisfactory fusion in young children, has been a prevailing opinion that there was not enough bone in the spinous processes and laminae to obtain an adequate arthrodesis of the spine.

In 1931 we were faced with the problem of finding suitable sanatorium facilities for an increasing number of young children with tuberculosis of the spine. It was obvious that these children would require from three to ten years of hospitalization. If they reached an age approaching puberty without satisfactory evidences of healing, an operation for fusion of the spine would be performed. Doctor Allison had been convinced by his own short series of failures that an operation for splinting the spine in young children was not justifiable. He believed that the failures were due to inadequate ossification in the spinous processes and the laminae of these children.

Embryologic studies were undertaken by Jerome and Compere to determine the age at which ossification of the vertebrae and their various appendages was complete. A study of microscopic sections of the spines of fetuses confirmed the statement of embryologists that ossification begins in the vertebral bodies at eight to 16 weeks. At the time of birth, the vertebrae consist of three pieces, the body and two halves of the vertebral arch, each of which has its own well developed ossification center. During the first year the halves of the arch (the laminae) unite behind, union taking place in the lumbar region and extending up through the thoracic and cervical region. About the third year the bodies of the upper cervical vertebrae are joined to the arch on either side. At birth the vertebral bodies near the intervertebral disks as well as the tips of the transverse and spinous processes are covered by a layer of cartilage. In this cartilage, epiphysial centers of ossification appear at the sixteenth or seventeenth year. Fusion is complete about the twentieth year. The line of suture is visible in the bodies for a year longer.

As a result of these studies, Allison became convinced that previous failures of operative procedures, both in his own hands, and that of others, had been due to faulty operative technic. As a result he encouraged us to begin operative fusion in all cases of tuberculosis of the spine regardless of the age of the patient. We are able to report a short series of cases which we have studied carefully, both before and after operation, during the three years since the new orthopedic center at the University of Chicago was opened.

The operative technic which we elected to use consisted of exposure of the spine, excision of part of the articular cartilage from the articular facets,

chiseling and turning curls and splinters of bone from the spinous process of the laminae laterally across the facets and from one lamina to another. A thick osteoperiosteal graft obtained from a tibia or a full thickness tibial graft with some additional osteoperiosteal strips was placed on the denuded laminae on both sides of the spinous processes. The spinous processes were then fractured and placed shingle fashion on top as an additional layer of bone (Fig. 2). In two of the patients operated upon, rib grafts were used instead of bone from the tibia.

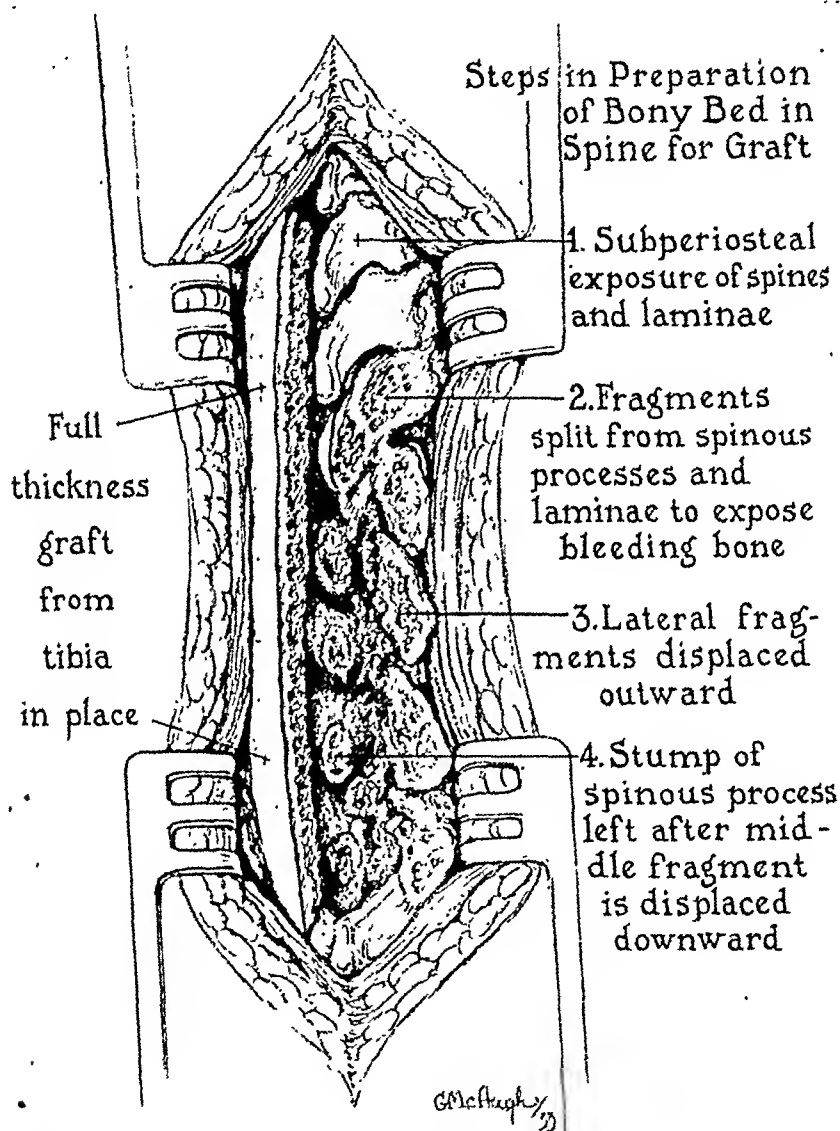


FIG. 2.—Diagram of operation for arthrodesis of the spine in young children.

REVIEW OF CASES

During the past three years we have operated upon the spines of 56 patients suffering from tuberculosis of the vertebral bodies. Twenty-eight of these patients were children 12 years of age or under.

In Table I we have listed 18 cases, ages one and one-half to nine years. There were eleven girls and seven boys. The duration of disease before operation was from six months to five and one-half years. Nine of the patients had been treated by plaster jackets, plaster shells and the usual supportive

measures, including fresh air, and in most instances sanatorium care for more than two years. Eight of the patients had been treated for more than five years. All of the cases still had active disease processes. The patients were malnourished and in two of them there was a well advanced amyloid disease

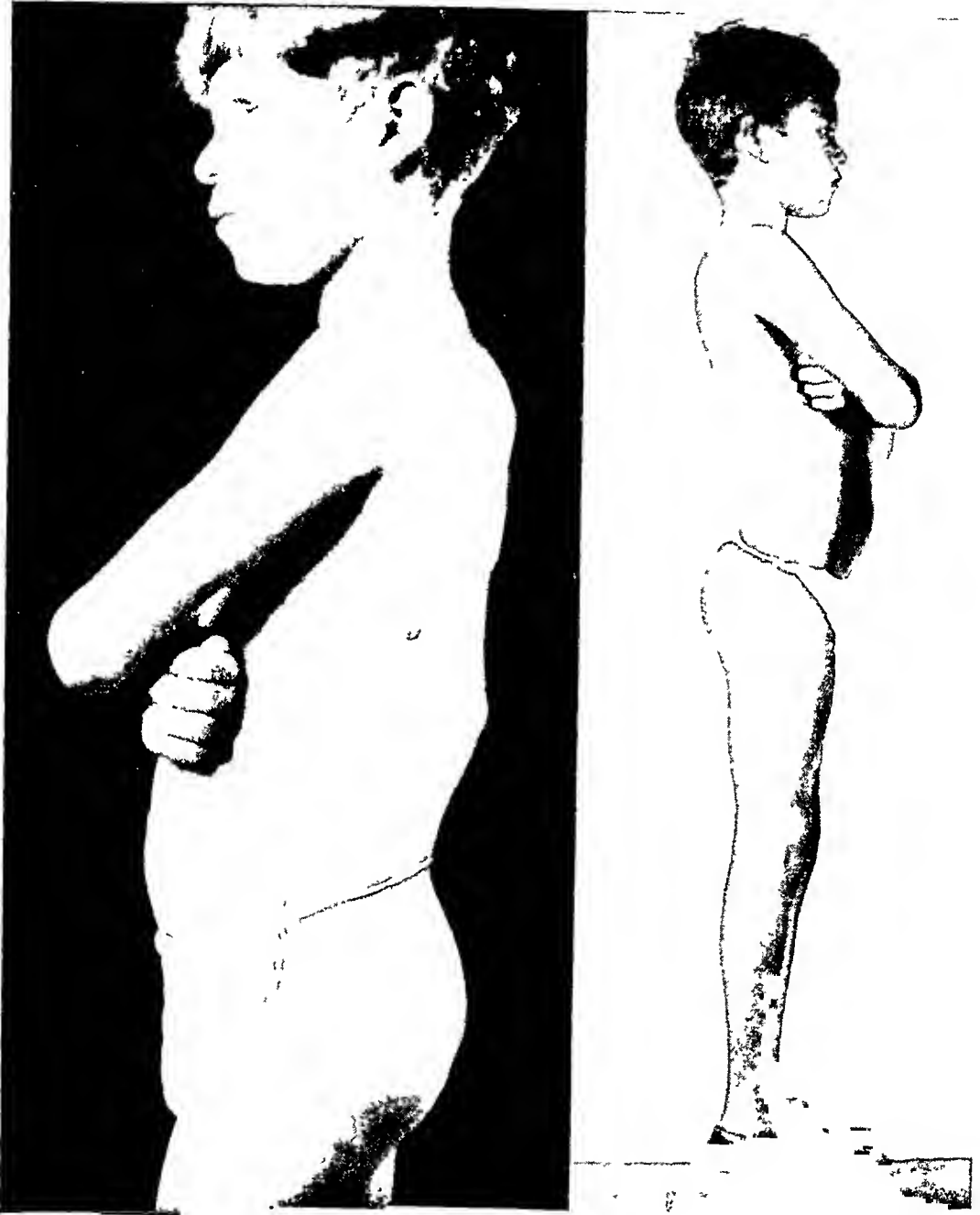


FIG. 3—C. A., aged 11. The kyphosis was corrected by a turnbuckle plaster cast and the spine was then arthrodesed to immobilize and maintain the correction. Patient is now clinically cured three years after operation.

with draining sinuses which had developed during the period of so called conservative treatment. Onset of the disease in all except one case was at the age of five years or under. The two patients who had an extensive amyloid disease survived the operation and for a time showed improvement. One of them gained 8.0 Kg. in 24 months and the other 2 Kg. in 12 months. This improve-

TUBERCULOSIS OF THE SPINE

TABLE I
Tuberculosis of Spine—Ages One and One-half to Nine Years

Case	Sex	Weight in Kg.			Time Elapsed	Age at Onset	Age When Operated Upon	Duration before Operation	Present	Deformity	Vertebrae Involved	
		Adm.	1-1-34	Gain							Level	Number
1. A. K.	F.	22.5	28.0	7.5	35 mos.	3	7	+ yrs.	11	Moderate	D12-L2	3
2. R. M.	F.	18.6	26.0	7.4	31 mos.	8	8	9 mos.	10	None	D 2-3	2
3. D. Y.	F.	13.2	21.0	7.8	33 mos.	1½	5½	+ yrs.	8	None	L 1-2	2
4. M. R.	F.	13.0	died	8.0	24 mos.	3	7	+ yrs.	9	Very mild	L 3-5	3
5. M. B.	F.	16.0	26.2	10.2	31 mos.	1½	6	4½ yrs.	8	Very mild	D11-L2	4
6. W. P.	M.	16.5	died	2.0	12 mos.	3	8	5 yrs.	9	Moderate	D 6-L2	9
7. W. C.	M.	17.5	21.0	3.5	30 mos.	5	6	8 mos.	8	Very mild	D 4-5	2
8. M. P.	M.	18.5	26.3	7.8	24 mos.	3	7	4 yrs.	9	Moderate	D 8-12	5
9. J. S.	F.	7.2	died	6.0	18 mos.	1	1½	7 mos.	3	Mild	D11-L1	3
10. D. S.	F.	18.5	23.6	5.1	33 mos.	3	5	2 yrs.	7	Mild	D 9-L3	7
11. P. K.	M.	22.0	30.0	8.0	30 mos.	3	8½	5½ yrs.	10	None	D 5-6	2
12. R. K.	M.	23.0	31.0	7.0	30 mos.	2	6½	4½ yrs.	8	Mild	D10-L1	4
13. J. G.	M.	18.0	27.5	9.5	30 mos.	3½	5	1½ yrs.	8	Mild	D 7-8	2
14. E. S.	F.	12.0	20.0	8.0	30 mos.	3	3	5 mos.	6	Mild	D 7-8	2
15. E. J.	F.	13.6	18.5	4.9	18 mos.	1½	3	3 yrs.	4½	Very mild	L 3-5	3
16. A. J.	F.	12.5	15.8	3.3	22 mos.	2½	3	6 mos.	5	Very mild	L 2-3	2
17. V. T.	F.	17.0	17.5	0.5	12 mos.	6½	7	6 mos.	7	Moderate	T 9-11	3
18. R. K.	M.	11.8	12.6	0.8	3 mos.	1½	2½	1 yr.	2½	Mild	L 1-2	2

ment was not lasting and both patients died of amyloid nephrosis. The third death in this group, which also followed a period of improvement with a gain in weight of 6 Kg. in 18 months, resulted from tuberculous meningitis four months after a second operation made necessary by a fracture of the earlier fusion. Each of the other 15 patients in this group showed progressive improvement. All of these are clinically healed at the present time. Deformities which were present have not been corrected but, with two possible exceptions, there has been no increase in kyphosis of the spine following operation. Those patients who were operated on before deformity occurred have not developed any angulation of the spine. All in this group have shown a satisfactory gain in weight.

Table II details the analysis of ten cases of tuberculosis of the spine in patients aged nine to 12 years, inclusive. All of these patients have shown improvement and the deformities which were present at the time of operation have not increased. In two instances we were able, by hyperextension, to partially correct the deformity and in one (C. A.) a rather marked deformity of D12 to L2 was corrected so that the patient has a normal spine curve both from the standpoint of gross appearance (Fig. 3) and in the roentgenogram. These patients have gained from six to 27 Kg. since operation. With one exception, they had been treated from five and one-half to ten years before operation by the so called conservative method of plaster jackets, plaster beds or Bradford frames, rest and the usual supportive measures. In spite of this treatment, the disease was still active, deformities in varying degrees had occurred, sinuses had developed and the patients themselves were undernourished or emaciated. The most striking change noted is that of a boy (L. D.) who, after ten years of conservative treatment, still had a persistently discharging sinus, deformity, and, at the age of 11 years, weighed only 28 Kg. The sinus, which healed within 30 days after the spine was fused, has remained closed. Clinically he is entirely well three and one-half years after operation and able to take part in various types of athletics. Again in this group we note that the number of girls is greater than that of the boys in a ratio of seven to three. The onset of disease in eight of the ten cases was before the age of five years.

There have been five deaths of patients suffering from tuberculosis of the spine (Table III). Two of these patients were not operated upon. One of these (E. H.), aged six years, died of tuberculous meningitis while being treated in plaster shells and the usual supportive measures in preparation for operation. The second (B. C.), died of generalized and pulmonary tuberculosis. One patient, aged three years, with pulmonary tuberculosis and tuberculosis of the spine, died of tuberculous meningitis four months after operation. Two patients who were seriously ill with amyloid disease and marked renal insufficiency at the time of operation survived for 13 months and two and one-half years, respectively, and during the first year or more after operation showed definite signs of improvement from the standpoint of their general nutrition and health. We believe that these two patients' lives could have been saved by an arthrodesis of the spine before renal damage had

TABLE II
Tuberculosis of Spine—Ages Nine to Twelve Years, Inclusive

Case	Sex	Weight in Kg.			Time Elapsed	Age at Onset	Age When Operated Upon	Duration before Operation	Pres- ent Age	Deform- ity	Vertebrae Involved	
		Adm.	1-1-34	Gain							Level	Num- ber
1. E. W.	F.	19.5	28.0	8.5	23 mos.	2	11	9 yrs.	12	Moderate	D 5-10	9
2. C. A.	M.	29.5	37.0	7.5	24 mos.	11	11	3 mos.	13	None	L 2-5	3
3. L. D.	M.	28.0	55.1	27.0	31 mos.	1	11	10 yrs.	14	Moderate	D 12-L2	6
4. S. S.	F.	22.0	38.5	16.5	30 mos.	3½	9	5½ yrs.	12	Moderate	D 8-12	5
5. R. K.	M.	17.5	28.1	10.6	31 mos.	4	10	6 yrs.	11	Moderate	D 9-L1	5
6. R. B.	F.	32.2	42.8	10.6	18 mos.	3	11	8 yrs.	12	Very mild	L 5	1
7. C. C.	F.	29.0	46.0	17.0	36 mos.	3	11	8 yrs.	13	Moderate	D 10-L1	4
8. J. S.	F.	20.0	25.5	5.5	30 mos.	3	11	8 yrs.	13	Moderate	D 8-12	5
9. M. T.	F.	31.0	44.7	13.7	30 mos.	2	10	8 yrs.	13	Mild	D 10-L2	5
10. S. W.	F.	21.0	27.7	6.7	30 mos.	7	12	5 yrs.	14	Moderate	D 11-L1	3

become so advanced. At autopsy we found that the spines in both instances were well fused and the tuberculosis of the vertebrae was quiescent (Fig. 4). These two patients had been treated by so called conservative measures and while under treatment they developed persistent draining sinuses. The concomitant amyloid nephrosis had hopelessly damaged the kidneys leading to death from renal insufficiency.



FIG. 4.—M. R., age six years. The clinical improvement continued for two years but, two and one-half years after operation, the patient died of amyloid nephrosis. Necropsy examination showed that the tuberculosis of the spine had been arrested.

TABLE III

Cause of Death

Cases 12 Years and Under When Operated Upon

Case	Cause of death	Age	Time after operation
J. S.	Tuberculous meningitis	3 yrs.	4 months
E. H.	Tuberculous meningitis	6 yrs.	No operation
B. C.	Generalized tuberculosis	12 yrs.	No operation
M. R.	Amyloid disease with nephrosis and secondary infection	9 yrs.	2 ½ years
W. P.	Amyloid disease with nephrosis	9 yrs.	13 months

In reviewing the series, we find that there were three deaths of patients who were operated upon, two from amyloid nephrosis and one from tuberculous meningitis. Fourteen patients are living and well, apparently entirely healed, 11 patients are definitely improved and have either been discharged

TUBERCULOSIS OF THE SPINE

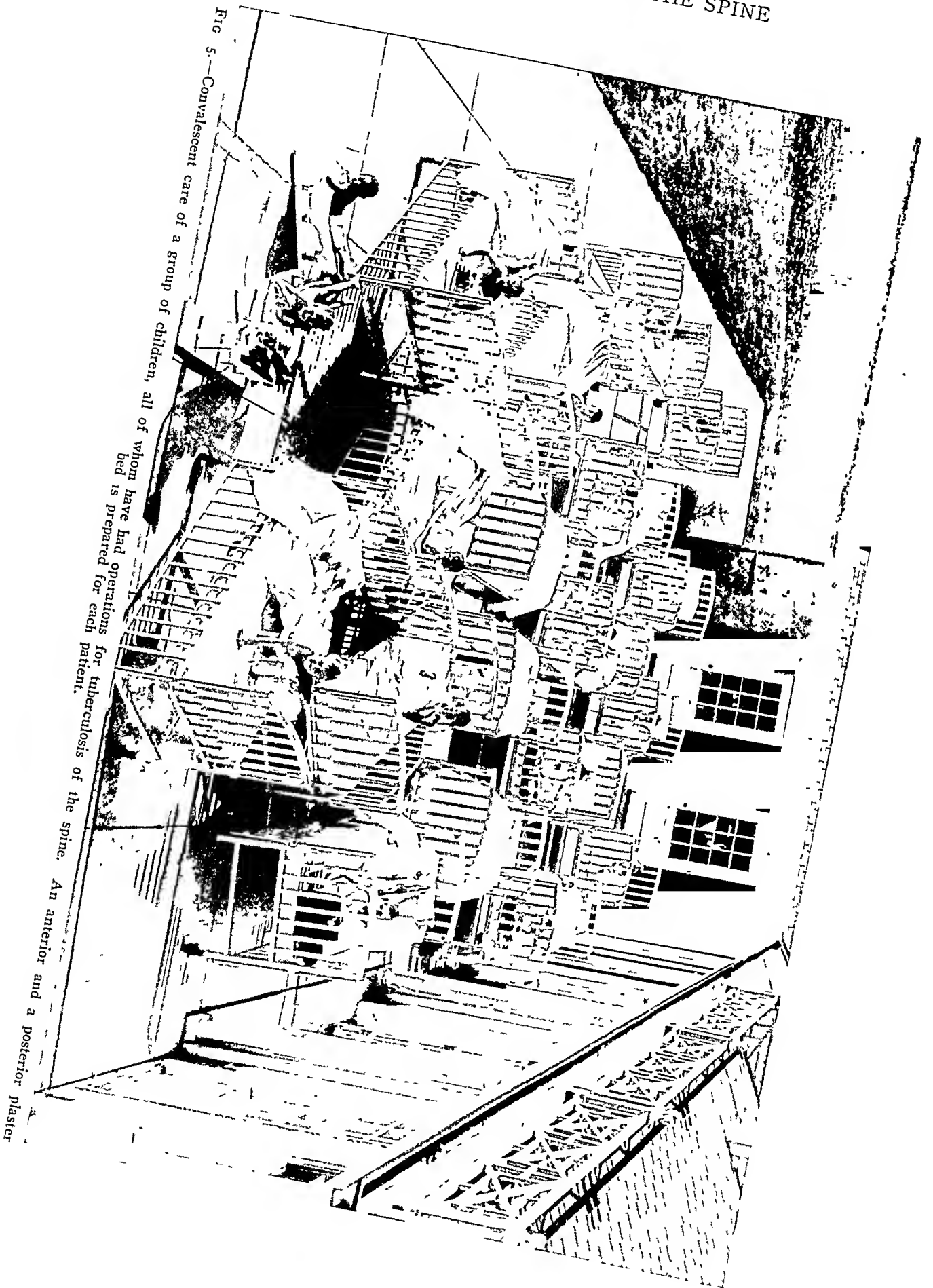


Fig. 5.—Convalescent care of a group of children, all of whom have had operations for tuberculosis of the spine. An anterior and a posterior plaster bed is prepared for each patient.

from our convalescent hospital (Fig. 5) or are ready now for discharge (TABLE IV).

TABLE IV

Number of deaths * (ages 2½ to 12).....	5
Number clinically healed.....	14
Number improved.....	11
Total.....	30

* Two of these patients were not operated upon.

SUMMARY

A critical attitude with regard to the advisability of arthrodesing operations in the spines of young children with tuberculosis of the vertebral bodies has been maintained throughout this study. We do not feel that we have had a large enough series or that we have followed these patients for a long enough period of time to be able to state positively that such operations in young children will lead to a cure in any fixed percentage of cases. We are convinced, however, that it is possible to adequately splint the spine in children at any age, even at the time of birth, if the operation is performed carefully; if enough bone is used, preferably full thickness grafts taken from the tibia; and if these grafts are long enough to reach at least two normal healthy vertebrae above and two healthy vertebrae below the diseased vertebral bodies. We are further convinced, from a study of the spines removed at necropsy where death has followed some intercurrent disease or complication, that this splinting is adequate to prevent motion in the joints between the diseased vertebrae and to protect the disease softened vertebral bodies from the trauma of weight bearing. We have also emphasized the importance of adequate supportive measures before and after operation, such as long periods of rest, preferably in plaster shells; high caloric and high vitamin diets; heliotherapy; and fresh air to improve the health of the body as a whole.

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A MODIFICATION OF THE OPERATION FOR SPINAL FUSION

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REFERRING to the operative measures for fixation of the spine, two problems arise which require consideration: (1) The rôle of the graft and of the operation itself. (2) The operative technic and postoperative treatment.

As to the first problem, the opinions of the authors can be divided into two groups. The first, Albee, Tuffier, Ombrédanne, Le Fort, Basset, Haeblerlin, Dubois, Dardel, Lauvers, Sebrechts, Schramm, H., Hanson, Maffei, Spišić, Calandra, Courcy, Wheeler, *etc.*, are of the opinion that the bone graft undoubtedly exerts a favorable biologic influence, to the rapidity and completeness of the healing of the specific lesions. The bone transplant is supposed to possess a greater ability of bone production (Albee) than the laminae and to cause a local change in the calcium metabolism and protracted hyperemia. Tavernier suggests some supplementary principle, not closely defined. Leriche, Allenbach, Dieulafé, Juvara and Cocacescu consider that the biologic influence of the graft is probable.

The second, the larger group of authors, Massard, Chevalier, Moutier, Calvé, Galland, Constantini, Bressot, Leclerc, Willmoth, Brandes, Elsner, Deutschlander, Cortes, Llado, Pujoi, Georgesen, Jacobovici, Bristow, Biesalski, Henderson, Delitala, Scherb, Delchef, Minař, Jovčić, Sorrel, Richard, *etc.*, consider the rôle of the graft to be an exclusively mechanical one. The basis for this standpoint is the lack of evidence for the existence of such a biologic influence, the impossibility of comparing and conjecturing the course the case would undergo without a surgical treatment, finally a series of anatomico-pathologic examinations of specimens taken from a few months up to a few years after operation, which revealed the existence of unhealed specific lesions in the bodies of the vertebrae, despite the perfect fusion of the transplanted bone.

The study of cases of peri- and paraarticular arthrodesis in cases of tuberculosis of the hip joint leads to the conclusion that the existence of a biologic influence which enhances the rapidity and completeness of healing is undoubtable. This influence is the more remarkable, the closer to the lesion the graft is inserted. Clinically this influence manifests itself by an increased reproduction of bone tissue in the foci, their reduction in size, the rapid union of the bony ends and the rapid recalcification of the entire region. A more profound consideration of these phenomena would require detailed studies. In general the process resembles the phenomena observed in the healing of fractures—active hyperemia lasting weeks and even months, transposition in the contents of calcium salts in the particular parts of the operated region, from the graft

to the diseased tissues, in fractures to the callus—the undoubtable increase in the ability of bone formation in the region of the graft.

All these phenomena take place in that space of time, in which the graft, not being entirely fused, plays no mechanical rôle. Taking the above-mentioned observations under consideration in connection with the measures of fusion of the spine in order to enhance the mentioned biologic influence, the graft should be placed as close as possible to the tuberculous lesions, at least in the sphere of the laminae of the spine.

Referring to the conception of the second group of authors, the mechanical rôle of the graft does not begin until the graft is definitely fused. According to the investigations of Hoessly, Mayer and observations of many others, the definite fusion of the graft does not take place sooner than eight to ten

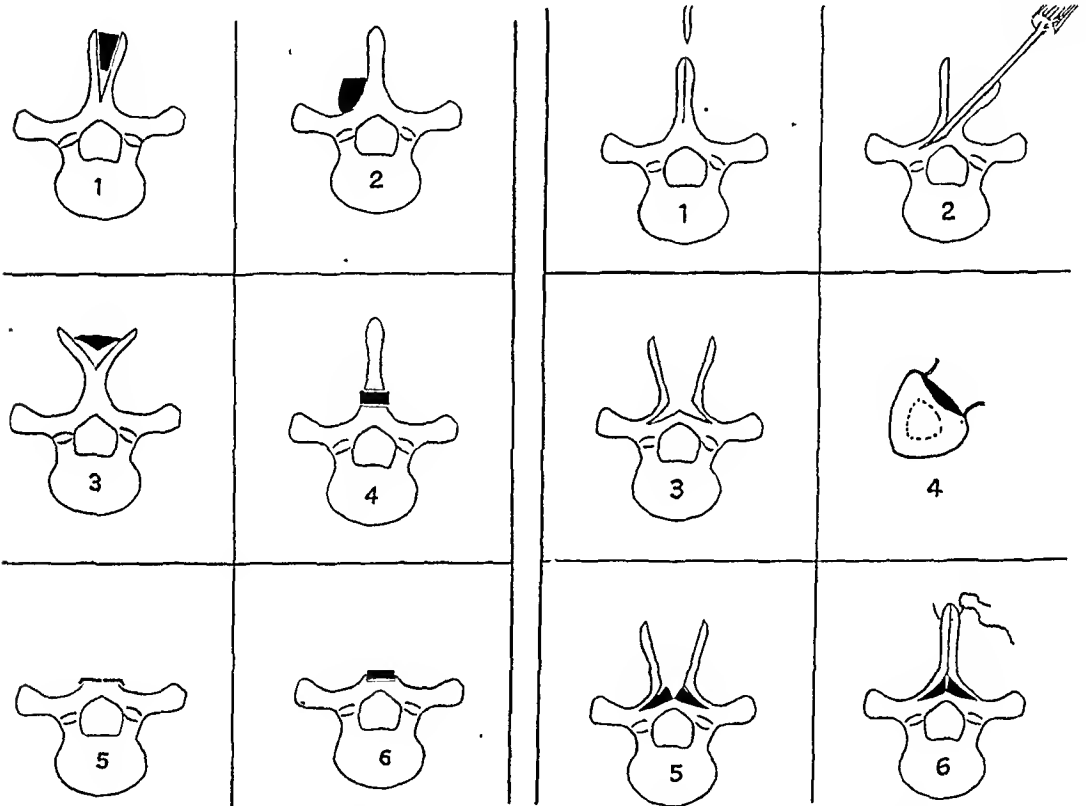


FIG. 1.—The methods of fusion operations of the spine. (After Sorrel.)

FIG. 2.—The author's method.

months after operation. Four months after operation the graft is the weakest and most liable to break. Therefore the weight bearing of the graft should not take place sooner than five to six months after operation. This standpoint is undoubtedly sound, if the graft is to perform its mechanical rôle.

Certain differences must arise in connection with the different methods of operating. Here we come to the second problem: In most methods, advising autoplasmic grafts, the relation between the graft and its bed is for a long time quite loose. The graft is in contact with its base only in some of its parts (Fig. 1; 1, 3, 4), or with one surface only (Fig. 1; 2, 5, 6). Therefore the revitalization of the graft proceeds slowly. Entirely different conditions exist

in the osteoplastic methods such as that of Hibbs and its modifications. Fixation is already strong, when the production of callus takes place, that is six to ten weeks after operation. In these methods, however the biologic influence is insignificant and of short duration as compared with the effect of a free autoplasic graft.

These considerations lead to the conclusion that the classic methods of both Albee and Hibbs should be combined and thus transfer the mechanical point of weight from the autoplasic graft to the callus produced in place. In this way the spine is immobilized within six to twelve weeks after operation.

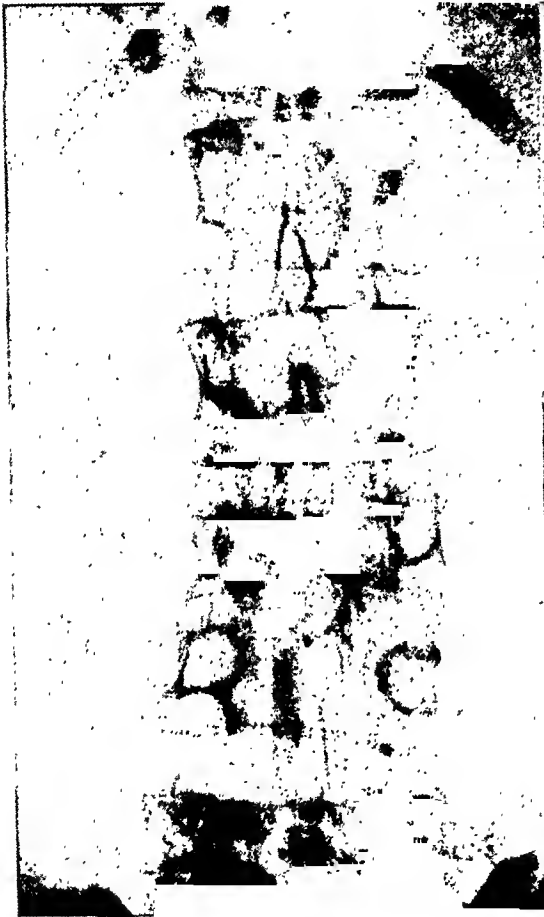


FIG. 3.—(Case I.) Anteroposterior view 16 months after operation. Showing implanted graft and apparent lack of vertebral pathology and smooth strong calcification.



FIG. 4.—(Case I.) Lateral view 16 months after operation. Showing fusion of both vertebrae.

During the subsequent months the firmness of this immobilization will increase, as the fusion of the graft becomes more solid. This has a practical meaning, for the patient may be allowed to walk about and even to perform light work two to three months after operation. The immobilization will be more secure, if besides the fusion of the processes as in Albee's method, or the fusion of the processes and laminae, we also obtain the fusion of the joints of the corresponding vertebrae as in Hibbs' method.

As a result of the above considerations the following operative technic for fixation of the spine has been developed. We operate only upon patients showing a fairly good general condition, prepared by lying a few months in a

plaster of Paris bed and by general treatment. The operation is usually performed under local anesthesia with 1 per cent novocaine.

(1) A semilunar skin incision is made of sufficient length to expose the processes of the diseased vertebrae and one above and below the diseased one. In the dorsal spine two vertebrae above and below. The skin flap is dissected up one cm. beyond the midline.

(2) Incision of fascia, supraspinous, interspinous ligaments and incision of the tips of the exposed spinous processes in the midline, splitting of the processes in halves (Albee's method) by means of a knife chisel, without the use of a hammer to a depth two-thirds to one inch, depending upon the operated region, but it must always reach the base of the processes (Fig. 2; 1).

(3) After all the spinous processes have been thus divided, they are set over to both sides together with the surrounding tissues; a chisel is next inserted at an inclination of 45° and the posterior surfaces of the laminae



FIG 5—(Case II) Before operation Showing extent of large abscess in dorsal region



FIG 6—(Case II) Before operation Showing destruction of facing surfaces of ninth and tenth dorsal vertebrae in bone tissue

are chiselled off as far as the base of the transverse processes in the dorsal spine region, in the lumbar spine as far as the mammillary processes. In the course of the chiseling the whole flap containing one-half the spinal processes and the laminae together with the muscles is retracted laterally and the base carefully trimmed, taking care to produce an abundance of bone chips which remain *in situ* and in the recesses of the wound (Fig. 2; 2). We repeat the same procedure on the other side (Fig. 2; 3).

(4) Into this prepared bed two tibial grafts without periosteum, $1\frac{1}{2}$ cm. wide by 2, 3 or 4 Mm. thick are implanted (Fig. 2; 5). The eventual breaking or splitting of the graft during its procurement is without significance.

(5) The retracted bone and muscles are replaced in their former position covering the grafts and are sutured between the spinous processes (Fig. 2; 6). Next follows the suture of the fascia and skin.

Postoperative Treatment.—Six to ten weeks, depending upon the region operated, in a plaster of Paris bed, then four weeks in a plaster jacket and an orthopedic back brace up to a year.

We have applied this method of operation in 15 cases of tuberculosis of the spine and in two cases of fracture of the spine. The postoperative course was uneventful and mild. In all cases the wound healed by primary intention. One of the patients thus operated upon on account of Kümmel-Vernueil disease five months after a fracture of the spine, was up and walking about the third day after operation, although it was strictly forbidden. This fact, however, did not in the least affect the healing of the wound or the final result.

ILLUSTRATIVE CASE REPORTS

CASE I.—F. O., female, aged 19. The family history was negative. Present illness began about three years ago, with complaint of pain on the inner side of the left foot. She was twice operated upon. Seven months later she underwent an operation on account of



FIG. 7.—(Case II.) Fifty one days after operation. Showing degree of healing and regeneration in bodies of ninth and tenth dorsal vertebrae at that time.



FIG. 8.—(Case II.) Four and one-half months after operation. Showing continuation of reparative process.

abdominal hernia. The wound healed by secondary intention. Three years ago there was an abrupt onset of pain in the lumbar region of the spine. The pain periodically intensified and subsided and was present at the time of admission.

Local examination: In the region of the third and fourth lumbar vertebrae a slight protuberance and a mild degree of lumbar lateral curvature. The spinal processes tender to palpation. Pressure exerted along the spine caused pain in the lumbar region. Mobility of the lumbar spine limited. In the left iliac fossa a tumor, the size of a child's head, tender to palpation, fluctuating, smooth surface and not connected with the spleen. Roentgenographic examination revealed extensive specific destruction of the third and fourth lumbar vertebrae.

The patient was treated clinically from 5/12 to 12/12/1931. Her temperature ran up to 39° C. (angina, bronchitis). After this had subsided, she received invigorating treatment and was placed in a plaster of Paris bed. The cold abscess was punctured a few times and the pus evacuated. The patient remained in the plaster of Paris bed until



FIG. 9.—(Case II.) Eleven months after operation.



FIG. 10.—(Case II.) One and one-half years after operation.



FIG. 11.—(Case II.) Twenty-two months after operation.



FIG. 12.—(Case II.) Twenty-two months after operation.

May 12, when the described operation was performed. The postoperative course was uneventful. The wound healed by primary intention. June 30 the patient was placed in a plaster of Paris jacket. July 7 she was discharged. The patient removed the plaster jacket after one month, and without any bracing, returned to her work as a servant. A follow up examination 16 months after the operation revealed that the lesions in the spine were healed (Figs. 3 and 4), the general condition excellent and no complaints.

CASE II.—B. S. Diagnosis: Tubercular Spondylitis Thoracalis. Family history was negative. When 33 years of age, after a childbirth she complained of pains in the spine and foot. In the latter a sinus developed. A year later she left for Leysin, where she spent three years. She was given climatic and recumbent treatment. The wound in the foot healed. After her return her condition grew worse. She again left for Leysin, returning after ten months in a deteriorated condition. The pains were considerable, she could not walk and was confined to her bed. She stayed in bed one year before she decided to undergo an operation.

Entrance examination revealed a protuberance and tenderness to palpation and pain on motion in the region of the ninth and tenth dorsal vertebrae. The general condition was good. Roentgenogram showed a destruction of the facing surfaces of the ninth and tenth dorsal vertebrae, with a focus in the bone tissue the size of a plum. The outline of the lesion was indistinct. In the prevertebral space a large abscess was present (Figs. 5 and 6):

December 10, 1932, operation as above. Postoperative course uneventful, except that the temperature, for a larger time showed raised up to 37.3° C.

Follow up roentgenograms every few weeks showed a gradual and rapid filling in of the bone lesions and the reduction of the cold abscess (Figs. 7 and 8). The patient, on her own request, remained in the plaster bed for five months. After the sixth month she wore an orthopedic corset. Follow up examination November 15, 1933: the spine at the level of the affected vertebrae is stiff, the patient has no pain. The general condition is excellent. A roentgenogram shows a highly advanced regeneration and recalcification of the vertebrae. The implanted grafts outline distinctly. The mass of the cold abscess reduced (Fig. 9). The last follow up examination December, 1934, revealed a clinical condition similar to that a year previous. The roentgenogram showed a practically complete disappearance of the foci in the bodies of the vertebrae (Figs. 11 and 12).

The operative method herewith described differs from other procedures in a few features:

- (1) It brings the point of action of the operation close to the diseased lesions in the bodies of the vertebrae.

- (2) The implanted graft is situated almost entirely within bone tissue.

- (3) Fusions of the laminae, joints and the spinous processes proceed rapidly.

- (4) The operation does not damage any of the elements normally immobilizing the spine, such as the ligaments, muscles, *etc.*

- (5) The biologic influence of the graft, due to its situation close to the foci and within the bone tissue, is rapid, conspicuous, and of long duration.

LIGATION OF VARICOSE VEINS*

AMBULATORY TREATMENT PRELIMINARY TO SCLEROSING INJECTIONS

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WITH the increasing popularity of sclerosing solutions, there has been a tendency to neglect essential surgical procedures in the treatment of varicose veins. However, as experience was gained with the injection method, many recurrences were noted. Their number varied from 10 per cent (de Takats¹) or 15 per cent (Cooper²) to 98 per cent of those followed for one year or more (Howard, Jackson and Mahon³).

The recurrence usually appears in the patient with large varicosities, in which the valves of the saphenous or of the communicating veins are incompetent. The thrombus produced by the sclerosing solution is not able to withstand the constant hydrostatic pressure from the column of blood in the vein above, which de Takats, *et al.*,⁴ found to be as much as 210 cm. of water with the patient standing. This pressure may be increased by coughing, straining at stool, and other actions producing an increase of intra-abdominal pressure. There result then an early canalization of the thrombus and a gradual reappearance of the varicose veins.

It became evident, therefore, that in order to produce a cure in many cases of varicose veins some method should be adopted which would remove the factor of pressure from above upon the thrombus. de Takats⁵ was the first in the American literature to call attention to the work of Moszkowicz,⁶ who suggested the combination of vein ligation with injections. de Takats believed that ligation was indicated especially in cases where the saphenous was dilated and had incompetent valves above the knee (Trendelenburg +). He was doubtful whether ligation was of value in those cases where the valves of both the saphenous and the communicating veins were incompetent (Trendelenburg ++). His patients were ambulatory throughout their treatment.

Since 1930 ambulatory ligation has been practiced at the Varicose Vein Clinic of the University Hospital. It is the purpose of this paper to report the results obtained in 226 ligations performed upon 178 ambulatory patients.

Indications.—At first ligations were performed only upon recurrences following injection, and upon large veins with incompetent valves of the saphenous and communicating veins which could not be readily treated by sclerosing solutions. The indications for ligation have been extended as experience with the method has increased. Ligations are performed at the saphenous opening on all cases in which the valves of the vein are incompetent (Trendelenburg +).

* Read before the Philadelphia Academy of Surgery, October 1, 1934.

LIGATION OF VARICOSE VEINS

In cases with large veins in which some of the valves of the saphenous are competent, ligation is performed at the highest palpable portion of the vein. The patients are tested by elevation of the extremity and pressure is made at the highest palpable or dilated portion of the vein. If the veins are

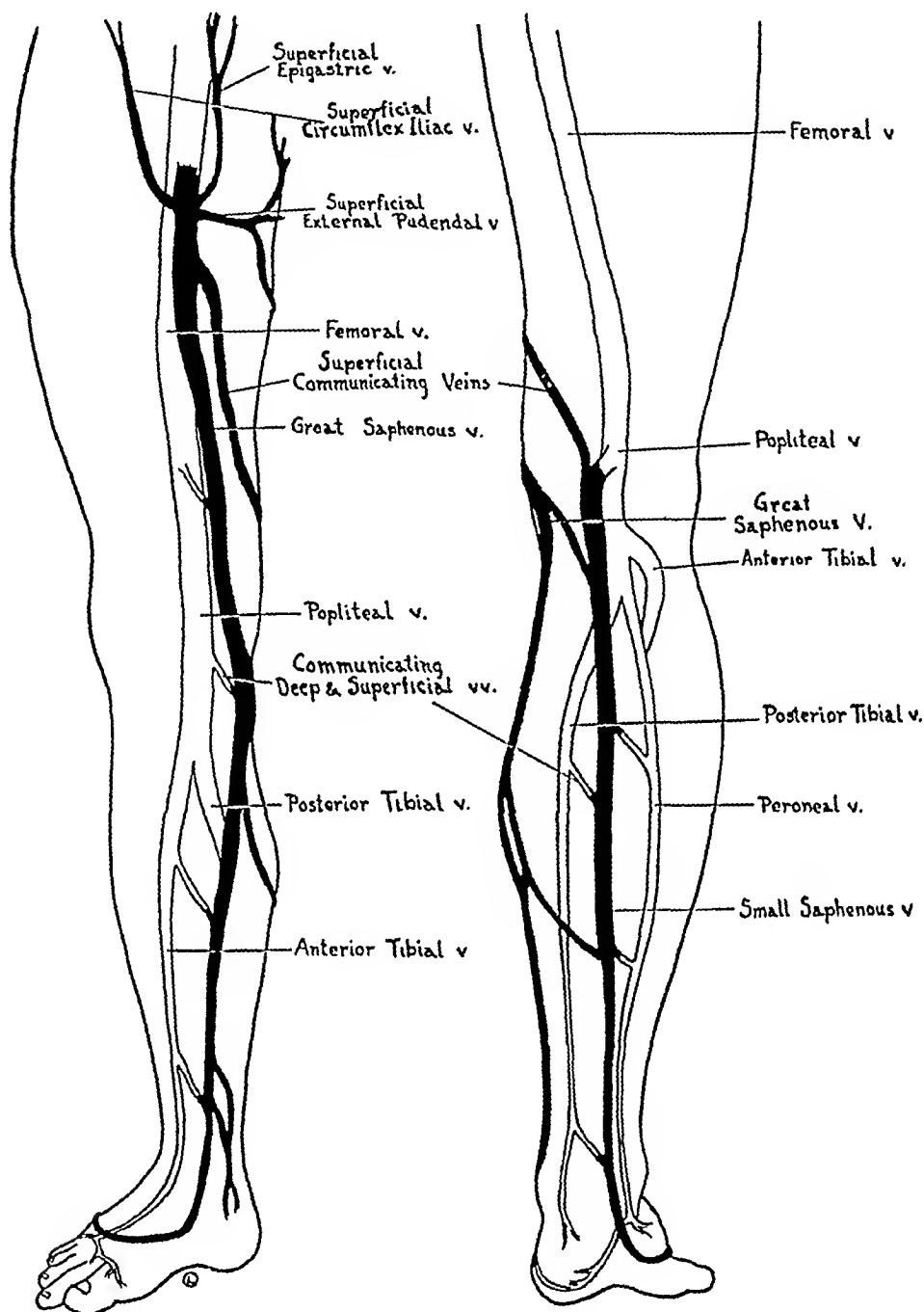


FIG. 1.—Diagrammatic representation of the superficial (black) and deep (white) venous circulations. Note the large anastomosing vessel between the small and great saphenous veins. The superficial circumflex iliac and superficial external pudendal veins at times empty into the upper end of the saphenous as shown and at other times directly into the femoral vein. The communicating veins are much more frequent than are shown in the diagram.

empty when the patient stands but fill rapidly from above when the pressure is released, the vein is ligated where the pressure was applied, whether it be above or below the knee. Ligations are performed on both the long and the short saphenous veins (Fig. 1).

In cases with incompetence of the valves of both the long saphenous

and the communicating veins, the long saphenous is ligated first, and, if the veins below are not readily thrombosed, the communicating branches are ligated where they join the superficial veins.

Ligations are performed upon and no injections are given patients who have a history of a superficial thrombophlebitis within the previous year. Injections are definitely contra-indicated in these cases and relief of symptoms may be safely obtained by ambulatory ligation.

Technic of Ligation.—The operation is a simple one and may be performed under local anesthesia. It is best to mark the site chosen for ligation with some colored solution while the patient is standing. A simple skin infiltration is made with 1 per cent procaine solution containing adrenalin. If the incision is made in line with the vein, better exposure is obtained and a greater length of vein may be resected. The incision should be carefully made through the skin because many veins are found lying attached to the skin with no intervening subcutaneous areolar tissue. As soon as the skin is cut through, small rake retractors are used to produce lateral traction, and the vein is carefully separated from the surrounding tissue by blunt dissection. As soon as possible a curved hemostat should be gently passed under the vein and, by traction, the underlying tissue may be separated from it. To permit easier dissection, the vein should then be divided between hemostats and each end turned back. As tributary branches are encountered, they are also divided between hemostats. It is especially important to find and clamp the branches communicating with the deep circulation. As much of the vein is dissected out as can be removed through an incision one and one-half inches long; often it is possible to remove as much as six or eight inches of a tortuous vein through such an incision. The main branches and tributaries are ligated with plain No. 00 catgut. Occasionally, in large veins, the upper end is doubly ligated. The wound in the subcutaneous tissues is closed with interrupted sutures of plain No. 00 catgut, which are inserted so as entirely to encircle the subcutaneous wound, thereby obliterating all dead space. The skin is closed with vertical mattress sutures of silk. A pressure dressing is applied.

In ligations at the saphenous opening it is well to expose the vein from below. After dividing it between hemostats, traction may be placed upon the upper cut end, making the dissection easier. When the superficial circumflex iliac and superficial epigastric or the internal pudendal veins empty into the upper end of the saphenous instead of directly into the femoral vein, these vessels should be caught and ligated to prevent recurrence through anastomosing vessels.

Postoperative Course.—At the completion of the operation, the patient is permitted to leave the hospital. She is instructed not to go to bed and is permitted to go about her usual duties. Occasionally, on the second or third day, there is some soreness which is due to a progressing thrombosis of the vein below the site of ligation, but the resulting discomfort is easily relieved by supportive elastic bandages. The sutures are removed on the fifth day.

In a few cases, from the third to the fifth day, there is an inflammatory reaction around the wound which readily subsides after the use of 70 per cent alcohol dressings and a supportive bandage. As a rule, following such an ambulatory ligation, there is a thrombosis of the veins below the site of ligation. This thrombosis may be progressive for a week or ten days but by the end of three weeks it becomes stationary. Hence, a period of three weeks is allowed to elapse after ligation before injections are given in the veins which remain.

Review of Cases.—Two hundred twenty-six ligations have been performed on 178 patients in the Varicose Vein Clinic at the University Hospital. The indications for ligation have been as follows:

Trendelenburg positive.....	131
Trendelenburg double positive.....	22
Recurrent after injections.....	11
Ulcer-feeding vein.....	13
Phlebitis.....	8

Ligations have been performed at the following sites:

Saphenous bulb.....	23
Saphenous bulb and leg.....	1
Midthigh.....	88
Thigh and communicating veins at knee or calf.....	15
Knee.....	44
Calf.....	37

Some patients have had one ligation on each leg or two or more on the same leg, as shown in the following table:

Ligations per patient	Ligations
Single ligations {right, 74 } {left, 44 }	118
One ligation each leg, 24	48
Two ligations same leg, 13	26
Two on one leg, one on other, 2	6
Three ligations same leg, 1	3
Two ligations each leg, 1	4

Age has been no contra-indication to ambulatory ligation.

16-30 years, 15 patients
31-40 years, 53 patients
41-50 years, 45 patients
51-60 years, 33 patients
61 and over, 16 patients

The youngest patient was a boy of 16 and the oldest a woman of 74 years.

Immediate Results.—The immediate results have been good. No deaths occurred. There were three infections of the wound, one of which necessitated bed treatment. One other patient was treated in bed for a time because of a painful descending phlebitis below the ligation. Mild inflammatory reaction about the wound, necessitating alcohol dressings, was

observed in 15 cases. Primary healing was obtained in 223 wounds. All of these patients were ambulatory. Many of them traveled several hours by auto or train to their homes without marked discomfort. The ligation does not keep the patients from performing their usual duties. As a rule, when the patients first stand, particularly on the second day after ligation, there is a moderate soreness which disappears as they walk. This discomfort is relieved if a firm supportive dressing is maintained.

The descending thrombosis occurring after ligation greatly reduces the veins to be treated by injection and the removal of the hydrostatic pressure from above makes the injections much more effective. The combination of primary ligation and secondary injection has therefore proved a more rapid method of therapy for large veins with incompetent valves. At the same time the advantages of ambulatory treatment are preserved.

The results of any treatment of varicose veins must be judged according to the aims of the therapy. These aims vary according to the symptoms to be relieved, which may be classified under three general heads:

(1) PAIN AND DISCOMFORT IN THE LEGS.

- (a) Pain, especially at the time of menstruation.
- (b) Ache after long standing.
- (c) Cramps in the legs, especially at night.
- (d) Pains and aches in knee and ankle joints associated with varicosities.
- (e) Heaviness and easy fatigue in the involved extremity.

(2) SYMPTOMS AND SIGNS PLAINLY DUE TO VENOUS STASIS.

- (a) Swelling in the legs after long standing.
- (b) Varicose ulcers.

(3) DISFIGURING VEINS.

- (a) Veins causing no symptoms, but treated for cosmetic reasons.
- (b) Veins causing symptoms indicated in groups 1 or 2.

In many cases the symptoms fall into two or three of these groups.

Follow Up Results.—A method of therapy for varicose veins cannot be judged solely by the immediate results. These are usually good in all methods. Certainly a follow up period of one year is insufficient to evaluate any method.⁵ A recent report of "not a single instance of recurrence" without a statement of the duration of the follow up period is of little value.² As a matter of fact, there hardly can be any time limit set for a cure of varicose veins comparable to the five year cure for carcinoma. It is probable that if observations are continued long enough in most patients with large varicosities, there will be a reappearance of some veins. This probability increases with the duration of the follow up period.

The treatments for varicose veins thus far suggested are intended to remove or obliterate the existing varicosities. None of them, however, remove the first cause of the venous enlargement, whether it be hydrostatic pressure from above transmitted through the femoral and other deep veins,

or an inherent familial weakness in the walls of the unsupported superficial veins. Hence, it would seem logical to expect the recurrence of the old veins or the appearance of new venous radicals which have become varicose since the treatment was given.

The results here presented concern ligations performed during 1930 and 1931, three- to four-year results. In practically all cases sclerosing injections were given following ligations.

During this period ligations were performed on 52 patients. Some of these were bilateral operations and in some cases two or more ligations were performed on the same leg. Twenty-six patients representing 37 ligations have returned for follow up examination, and the results are tabulated in the accompanying table. In all but two patients the painful symptoms have been relieved. There were signs of recurrent venous stasis in six patients. There were no enlarged veins in 11 cases. Eight patients had a few small veins in the calf. Six patients had a reappearance of the veins in the calf; before treatment, all of these had very large veins with double positive Trendelenburg tests. The ligations in this group were all at the saphenous opening or upper thigh. The recurrences were entirely in the calf; the veins in the thigh were well closed.

In evaluating these three- to four-year results, it may be said that ligation with subsequent injections was especially effective in relieving the painful and stasis symptoms. Reappearance of the veins in the calf occurred in 14 of the 26 cases, but in eight of these the veins were small and gave no symptoms. They were most marked in those patients who had had large veins with double positive Trendelenburg tests.

CASE REPORTS

THREE- TO FOUR-YEAR RESULTS OF 37 AMBULATORY LIGATIONS FOLLOWED BY INJECTIONS (26 PATIENTS)

CASE I.—Male, aged 64. Very large veins to saphenous opening for six to seven years (Fig. 2). Cramps, heavy feeling and swelling. Ligation at right saphenous opening; no injection. Slight immediate reaction. Three years later no pain, no stasis symptoms, recurrence of veins below knee (Fig. 3). Much improved.

CASE II.—Female, aged 56. Veins dilated to midthigh for five to six years (Fig. 4). Cramps, ache and swelling. Ligation in left thigh; one injection. Immediate result excellent. Three years later no pain, no stasis symptoms, no veins (Fig. 5). No trouble since operation.

CASE III.—Female, aged 41. Veins dilated to midthigh for 22 years. Cramps, ache and swelling. Ligation in left thigh; four injections. Good thrombosis tenth postoperative day. Four years later no pain, slight swelling, and few veins in the calf. Veins appeared after injury to leg one year ago.

CASE IV.—Male, aged 43. Large veins of calf "all of life." Easy fatigue, swelling and ulcer. Ligation at internal saphenous below left knee; two injections. Immediate result excellent. Three and one-half years later no pain, ulcer healed and very few veins. This patient is a ship's cook and wears bandage for protection.

CASE V.—Male, aged 60. Veins of both legs dilated to saphenous bulb for five to six years (Fig. 6). Easy fatigue, swelling and ulcer. Ligation in right leg; three injec-

tions. Ligation at left saphenous opening six months later; four injections. Immediate results excellent. Three and a half years after first ligation no pain, ulcer healed. Slight swelling of right leg and recurrence of veins below knee (Fig. 7). Patient feels well.



FIG. 2.—(Case I.) Trendelenburg positive. Saphenous vein enlarged up to saphenous opening.



FIG. 3.—(Case I.) Six weeks after ambulatory ligation. The mark on the lower calf shows the lowest level of thrombosis.



FIG. 4.—(Case II.) Large veins of the calf with double positive Trendelenburg test. Would not thrombose with injections.



FIG. 5.—(Case II.) Six weeks after ligation and one injection. No recurrence noted at examination three years after ligation.

CASE VI.—Female, aged 57. Midthigh dilatation of veins for 35 years. Pain, cramps and swelling. Trendelenburg double positive. Ligation in upper left thigh, also below left knee on same day; five injections. Slight immediate reaction. Three years later no pain, no stasis symptoms and no veins. Patient works daily as chambermaid.

CASE VII.—Male, aged 54. Large veins to upper thighs for five years. Easy fatigue and swelling. Ligations at left internal saphenous and in right midthigh on the same day; no injections. Patient in bed three days due to extensive postoperative thrombosis. Three years later no pain, no stasis symptoms and no veins.

CASE VIII.—Female, aged 45. Veins dilated to midthigh for 20 years. Cramps, pain and slight stasis symptoms. Ligation in left thigh; six injections. Immediate result good. Three years later no pain, no stasis symptoms and very few small veins. Patient "feels ever so much better."

CASE IX.—Female, aged 36. Smaller veins of calf for three years. Cramps but no stasis symptoms. Trendelenburg double positive test. Ligation in right calf; two injec-



FIG. 6.—(Case V.) Referred to clinic wearing truss because of large dilatations at the saphenous opening. Trendelenburg positive. Varicose ulcer, lower left leg.

tions. Immediate result good. Four years later no pain, no stasis symptoms and no veins. Patient well pleased from cosmetic viewpoint.

CASE X.—Female, aged 33. Large veins of long saphenous. Pain with periods, cramps and swelling. Ligation in upper right thigh; no injections. Veins entirely thrombosed. Three years later no pain, no stasis symptoms and some small veins. Patient feels well.

CASE XI.—Male, aged 37. Large veins of calf for 12 years. Pain, easy fatigue and swelling. Ligation at internal saphenous six inches below knee; no injections. Immediate result good. Three years later no pain, no stasis symptoms and no veins. This patient received injections at another clinic.

CASE XII.—Female, age unknown. Large veins to saphenous opening for 20 years. Pain with periods, ache and swelling. Ligation at right internal saphenous below opening;

no injections. Slight immediate reaction. Three years later no pain, no stasis symptoms and no veins. "Right leg is now the better of my two limbs."

CASE XIII.—Female, aged 53. Large cavernous veins for five years. Cramps, ache, swelling and ulcer. Ligations in both legs; four injections. Ligation in left mid thigh two years later; two injections. Four years after first ligations no pain, ulcer healed, no swelling and few small veins. Patient much pleased.



FIG. 7.—(Case V.) Three months after second ligation. Three injections were given in left calf.

no pain, no stasis symptoms and no veins. This patient has had several injections scattered throughout follow up period.

CASE XVIII.—Female, aged 49. Veins dilated to mid thigh for 12 years. Easy fatigue and swelling. Ligation in right thigh; three injections. Immediate result excellent. Four years later no pain, no stasis symptoms and no veins. This patient feels fine.

CASE XIX.—Male, aged 46. Large veins to mid thigh for 30 years. Heaviness, ache and swelling. Ligation in left thigh; five injections. Immediate result excellent with slight redness of wound. Four years later no pain, slight swelling and large veins. This patient had had previous excision of internal saphenous.

CASE XX.—Female, age unknown. Large veins for seven to eight years. Pain, "could not walk a block," swelling, ulcer. Ligation in right calf below knee; four injections. Immediate result good. Four years later no pain, ulcer healed and few small veins. Patient feels much better than before operation.

CASE XXI.—Female, aged 38. Large internal and external saphenous veins for 12 years. Ache, easy fatigue and swelling. Ligations in left thigh and below left knee on

CASE XIV.—Female, aged 52. Incompetent saphenous veins. Ache and swelling. Ligation in lower right thigh; four injections. Ligation in left leg about one month later; two injections. Immediate results good. Three years later no pain, no stasis symptoms and no veins. Patient considers herself cured.

CASE XV.—Male, aged 54. Veins dilated to mid thigh. Heaviness, ache, easy fatigue and swelling. Ligation in right thigh; three injections. Immediate result good. Three years later no pain, slight swelling and partial recurrence of veins. To have further injections.

CASE XVI.—Female, aged 32. Disfiguring veins in both legs. Ache with periods. Ligation in right thigh; two injections. Ligation in left knee about one month later; one injection. Immediate results good. Three years later no pain, no stasis symptoms and few small veins. To have further injections for cosmetic reasons.

CASE XVII.—Female, aged 30. Moderate dilatation to knee for six months. Pain with periods. Ligation in right thigh; six injections. Thrombosis above ligation. Four years later

same day; four injections. Symptoms relieved. Four years later no pain, no stasis symptoms and partial recurrence of veins. To have more injections.

CASE XXII.—Female, aged 52. Veins dilated to midthigh for eight years. Ache and slight swelling. Ligation in left thigh; no injections. Four years later no pain, no stasis symptoms and no veins. Patient "had forgotten about veins."

CASE XXIII.—Female, aged 51. Large veins for 15 years. Pain, cramps and swelling. Ligation in right thigh; one injection. Ligation at right knee one year later; two injections. Three years after first ligation no pain, no stasis symptoms and no veins.

CASE XXIV.—Female, aged 38. Large veins of both thighs for 20 years. Pain in legs and swelling. Ligation in upper left thigh; no injections. Ligation in upper right thigh one year later; no injections. Immediate results good. Three years after first ligation pain, swelling and few small veins. This patient had marked thrombosis below ligations.

CASE XXV.—Female, aged 35. Veins dilated to midthigh for ten years. Ache, easy fatigue and slight stasis symptoms. Ligation in right midthigh; three injections. Ligation in left midthigh; five injections. Good thrombosis following ligations. Three years later ache, easy fatigue, slight swelling and partial recurrence of veins. To have more injections.

CASE XXVI.—Male, aged 36. Large veins of calf for four years. Pain, swelling and ulcer. Ligation at left inner knee; five injections. Immediate result good. Three years later no pain, ulcer healed and no veins. This patient has no symptoms.

SUMMARY

In treating patients who have large veins with incompetent valves (the Trendelenburg positive case) injections of sclerosing solutions alone are not satisfactory because of the early canalization of the thrombus caused by the hydrostatic pressure from above.

The indications for ligation preceding injections are the Trendelenburg positive and double positive tests, recurrences after injections, ulcer-feeding veins and phlebitis.

The technic of the operation is simple and may be safely performed on ambulatory patients.

The results of the treatment must be judged according to the symptoms to be relieved and not solely upon presence or absence of veins after treatment.

The three- to four-year results in 26 patients treated by ambulatory ligation and subsequent injection may be tabulated as follows:

Symptoms	Relieved	Recurrence
Painful.....	24	2
Stasis.....	20	6
Disfiguring veins.....	12	8 (few small in calf) 6 (reappearance in calf)

The treatment of large varicose veins by ambulatory ligation followed by injection is recommended as rapid, effective and safe. The end-results compare favorably with those treated by other methods.

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BRIEF COMMUNICATIONS AND CASE REPORTS

AVULSION OF THE SCALP

TREATED WITHOUT GRAFTING

THOMAS O. OTTO, M.D.

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IN THIS industrial and automotive age it is not uncommon to see patients who have had the misfortune to lose by accident a large area of the scalp. This loss of tissue may or may not be associated with a denudation of the pericranium, and in either instance, presents a trying surgical problem. Usually the forces producing an avulsion of the scalp macerate the tissue to such a degree that its replacement is impossible.

The primary object is hemostasis, treatment of shock and the prevention of infection, since the liberal anastomosis of the emissary veins and sinuses, via the veins of the diploe, may readily result in a fatal meningitis. Dr. John Staige Davis¹ has reviewed in detail the history, etiology, anatomic considerations, mechanism, complications, prognosis and usual methods of treatment employed in avulsion of the scalp. The case herewith presented illustrates an approach in the treatment of extensive avulsion of the scalp without the aid of grafting, and shows what can be accomplished if one appreciates the great degree to which the remaining scalp may be stretched, if mobilized and drawn together in multiple stages, allowing sufficient interval for compensation in the marginal scalp.

CASE REPORT

Catherine F., aged 11, white, entered the Jackson Memorial Hospital, Miami, Florida, June 5, 1933, with a history of having caught her hair in the wringer of an electric washing machine. An extensive area of the scalp covering the crown of the head had been avulsed. Hemostasis was effected, the skull painted with a 5 per cent solution of gentian violet and a pressure bandage applied in the outpatient department. Shock was there combated and antitetanic serum, 1,500 units, administered the next morning. The dressings were changed to continuous wet ones of half strength Dakin solution. Some temperature and serum sickness delayed operative intervention for one week. The denuded area measured $12\frac{1}{2}$ cm. transversely and $14\frac{1}{2}$ cm. in the antero-posterior direction (Fig. 1). Virtually all the pericranium underlying the avulsed area was lost.

June 14, 1933, under basal avertin anesthesia with supplemental nitrous oxide-oxygen, a tourniquet was applied around the head just above the ears and the scalp margins mobilized down to the supra-orbital ridge anteriorly, the occipital protuberance posteriorly, and laterally to the subtemporal fossae. The margins of the remaining scalp were then drawn toward each other by means of mattress sutures through lead buttons.



FIG. 1.—One week after accident, before attempt at closure.

FIG. 2.—Result of first stage, showing lead button mattress suture across rubber tube with reduction of open wound to one half the diameter as shown in Fig. 1.

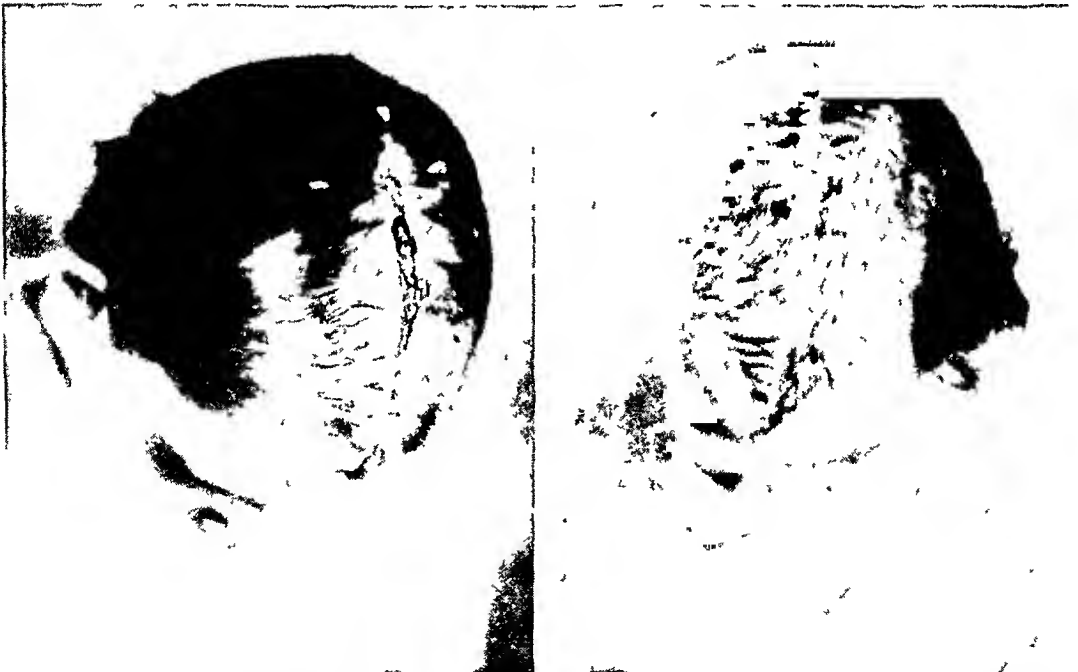


FIG. 3.—Result of second stage two months following the first stage as shown in Fig. 2.

FIG. 4.—Showing result after third stage with complete closure of scalp and without distortion of face or ears.

across a hemisection of rubber tube drain, so as to maintain a constant tension on the margins of the scalp (Fig. 2). This procedure reduced the transverse diameter of the avulsed area to 6 cm., virtually one-half of its original size.

The patient's postoperative course was uncomplicated and she was discharged June 25, three weeks after admission to return at two-day intervals for dressing. She was readmitted August 9, 1933, two months after the accident, and a second stage operation, identical in procedure, was done August 12, 1933. The wound had now been reduced to a granulating area varying from 1 cm. to 3 cm. (Fig. 3). She was discharged August 23, 1933.

After nine months the contour of the head and facial expressions were normal despite the great stretching of the scalp, and the head was covered with normal hair. June 29, 1934, the remaining portion of scar tissue was removed, allowing an exact apposition of full thickness hair bearing scalp, with only a linear scar remaining as evidence of the loss of tissue from the head. (Fig. 4). Nine months later there were no evidences of defect and no distortion of features (Fig. 5).



FIG. 5—Showing result nine months after third stage without further operation.

CONCLUSIONS

(1) The scalp has moderate mobility and elasticity permitting marked stretching.

(2) The abundant blood supply of the scalp will permit marked suture tension without sloughing and resists infection.

(3) Many cases of extensive avulsion of the scalp can be successfully treated without grafting if the above principles are employed.

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A MODIFIED CORONAL INCISION

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THE coronal or so called autopsy incision is sometimes used when it is necessary to turn down bilateral, frontal osteoplastic bone flaps as in the Naffziger operation (intracranial orbital decompression for malignant exophthalmos).

The usual straight coronal ear to ear incision was made in several of our cases. In one patient an infection occurred at the end of the incision in which

the tissues had been devitalized due to the acute angulation which occurred when the scalp was kept reflected for a long period of time. Also difficulty was experienced in keeping the scalp far enough forward without the use of strong retraction so that the anterior edge of the flap could be made close enough to the supra-orbital margin.

The essential objection, however, to the straight coronal incision is that a very acute angle is formed in the end of the incision with a resultant strangulation of vessels in that immediate region after the scalp has been reflected. This results in damage to tissues and predisposes to wound infection. In Fig. 1, *a* and *b*, the straight type of coronal incision is shown. In the same figure

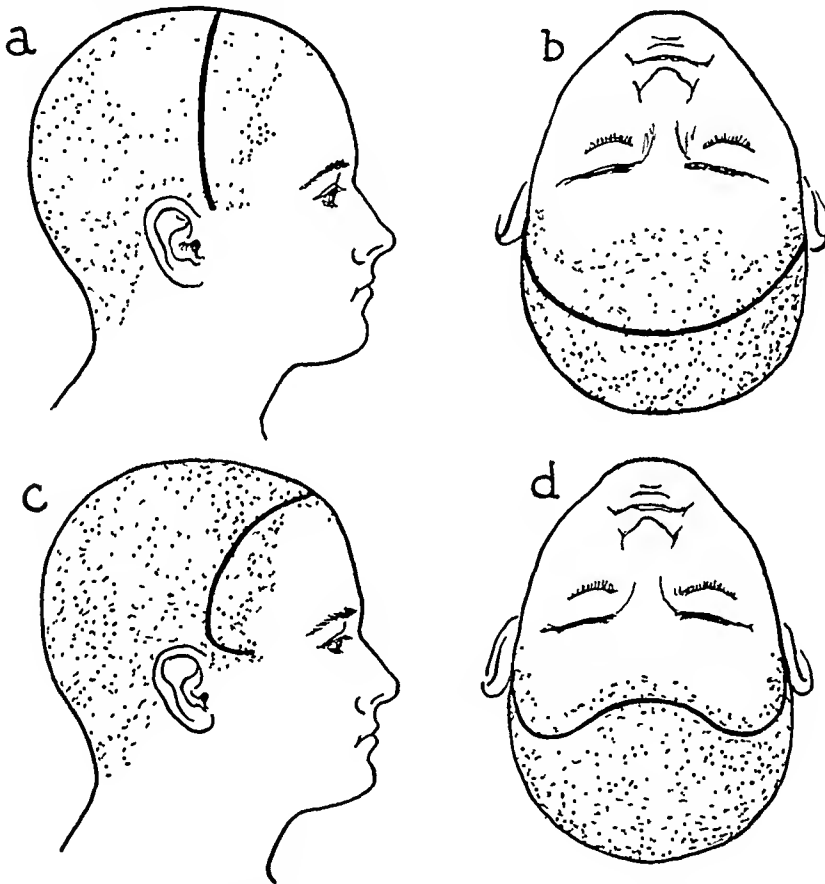


FIG. 1 (*a* and *b*)—Showing the old or straight type of coronal incision.
(*c* and *d*) Showing the new or modified type of this incision.

c and *d* demonstrate the curved type which allows the scalp to lie in place without retraction after it has been reflected. As can be seen, the superficial temporal vessels are divided but adequate blood supply to the flap is assured through the supra-orbital vessels.

The incision is started about 3 cm. posterior to the external canthus of the right eye, practically at the level of the helix of the ear. The incision is kept about 2 cm. behind the normal hair line following its natural curve. Precautions are taken to carry the incision just through the aponeurotic fascia so that in reflecting the scalp by sharp dissection a fairly thick layer of sub-aponeurotic tissue is left. This facilitates suturing the osteoplastic bone flap

back in position and enables the burr openings in bone to be covered by this tissue, thus preventing unsightly depressions. If blunt dissection is used there is a tendency to strip the subaponeurotic tissue off the periosteum. The latter is frequently so fragile that it cannot be adequately sutured. Through and through suturing of the bone can be done but is not necessary if a sufficiently thick layer of subaponeurotic tissue is left. The latter was emphasized frequently by Cushing.

The advantages of the above incision are: (1) It causes less strain at the end of the incision, thus reducing the incidence of wound infection. (2) It allows the turning down of bilateral osteoplastic bone flaps without the use of retraction. (3) It gives a more adequate exposure in the temporal region during the bone work.

BOOK REVIEW

ATLAS OF PATHOLOGICAL ANATOMY. Compiled by E. K. MARTIN, M.S., F.R.C.S. Under the direction of the Editorial Committee of the British Journal of Surgery. Bristol, Eng., John Wright & Sons, 1930.

A work intended primarily for the general surgeon. In this volume are considered Tumors of Bone, Diseases of the Breast, Stomach, Kidney, Gall Bladder, Bile Ducts and Inflammatory Lesions of Bone. The illustrations are in color and monochrome and are uniformly good. They depict the lesions clearly and comprise both microscopic and gross lesions, the latter drawn from museum specimens. Although the author states no attempt was made to include the rarities and curiosities of surgical practice, several unusual specimens have been presented, namely, an unusual case of Syphilis of the Stomach and one of Polyposis with Intussusception of the same organ.

The concise histories with each case and the descriptive text concerning each specimen are especially valuable. No fault can be found with the general arrangement which conforms with the standard for this type of work.

It is the reviewer's opinion that the Atlas would be a valuable addition to the surgeon's library.

THOMAS A. GONZALES, M.D.

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NON-OPERATIVE TREATMENT OF PERIPHERAL VASCULAR DISEASES*

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THE management of peripheral vascular diseases has been the subject of greatly increased interest during the past few years. This has been due, in part, to a realization that the vast majority of these cases, which formerly were problems of concern to physicians and surgeons only after some acute disturbance such as intermittent claudication or threatened gangrene had developed, are now appreciated to be preceded by a long period of a diminished circulatory reserve which should be detected and all efforts made to prevent the catastrophe of an amputation.

New procedures and new devices for estimating peripheral circulatory deficiency have been greatly improved, which, when properly applied, will materially aid in the detection of vascular disturbances long before the development of the clinical symptoms. We refer particularly to the use of the oscillometer and the thermocouple. The use of these instruments of precision, a pertinent history relevant to the aches and pains in the extremities and palpation of the pedal pulses; are slowly becoming a part of the routine of a complete physical examination.

There is today a greater desire as well as effort to try to prevent the amputation of extremities. This changing attitude of the medical profession has been brought about by many factors. The thousands of people unmindful of the fact that they have no pedal pulses have naturally brought up the question as to why the actual sufferers from peripheral vascular diseases cannot be tided over into a similar state of circulatory balance. Observations are accumulating which seem to justify the belief that the vast majority of our serious problems of peripheral vascular diseases result from a speeding up of the usual slow progressive occlusion of vessels or from an insult through trauma, infection or cold, which throw not only an acute strain on the collateral vessels but induce a period of vasospasm. This more or less sudden demand on the collaterals plus vasospasm of varying intensity give rise to the severe pain and gangrene unless the patient or the doctor or both can do something to tide them through these critical phases of the

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disease. A typical example is the cadaveric, vasospastic extremity resulting from a sudden arterial embolism or severe traumatism. The same process is repeated with varying clinical manifestations when the occlusion is only relatively rapid as a result of thrombosis of diseased arteries. A series of such events is witnessed repeatedly in cases of thrombo-angiitis obliterans. It is well illustrated by a patient who went through four distinct periods of threatened gangrene, each associated with a rapid occlusion of the tibial arteries, who then came to a circulatory balance adequate to give comfort the rest of his life, or in a patient with Raynaud's disease who, through extraordinary care, prevented a serious attack of angiospasm for a period of years. Observations such as these, together with the recent additions to therapy, such as sympathetic nervous system surgery and the use of passive vascular exercises, have made many surgeons change from the placid rôle of waiting for the time to amputate to an active rôle of trying to tide sufferers from peripheral vascular disease through to a stage of a comfortable circulatory balance such as we not infrequently see in people who have had a gradual yet extensive occlusion of their major arteries. We wish to consider these nonoperative forms of therapy which often help to prevent complications, relieve suffering, avoid amputation and establish a circulatory balance which will afford comfort.

From what has been said it is obvious that the great opportunity in this field rests in the early recognition of peripheral vascular deficiency. When it has become customary to study the peripheral vessels and to advise the patient when there is apparent a thin margin of safety in the blood supply of extremities, there are many things which can be done to avoid those critical periods of pain, infection, gangrene and amputation.

Many of these measures were popularized by Buerger and Allen, particularly the avoidance of injury and infection; the absolute necessity of keeping the feet warm; the immediate and most meticulous care of the slightest wound infection; keeping the skin of the feet in the most perfect condition by means of baths and oils; the avoidance of positions or active exercises which may tend to traumatize the main arterial pathways; a very large fluid intake; a judicious use of thyroid extract when the pulse is slow and the blood pressure low; the eradication of all foci of infection; abstinence from the use of tobacco; teaching patients the positions of optimum circulation when at rest, both lying and sitting down and Buerger or Allen active vascular exercises, *etc.* The difficulty in having these procedures carried out seems to be that few doctors have the time or patience to get patients to realize their importance and to establish them as a routine part of their lives. Many acute crises could be avoided if early diagnoses were made and these measures diligently practiced. The most meticulous observance of these measures of general care is among patients who have weathered periods of acute crises accompanied by severe pain or threatened gangrene. After such experiences it is not so difficult a matter to make patients realize the im-

portance of the many precautions and details of treatment that should be observed.

The time will certainly come when these measures will be employed extensively to lessen the first occurrence of the critical periods of peripheral vascular diseases. An advance will occur when doctors and patients evaluate the seriousness of the early disturbances of threatened occlusion. Then both time and effort will be devoted to tiding people, afflicted with peripheral vascular diseases, through to a state of more or less stationary circulatory balance consistent with activities which, of course, may have to be reduced. At the present time, only a few physicians are regarding these early disturbances seriously or doing anything particularly about them except when the critical periods of pain or threatened gangrene develop, and even then many patients are allowed to return to their former routine of life with only the most vague notions of what to do to prevent a recurrence of such experiences.

Preventive measures are rarely formulated until after a long period of actual combat with the fully developed disease. This has been true in most of our medical problems and seems to be necessary in order to kindle the interest from which eventually spring efforts in the field of preventive work. We are now at the stage of the beginning of active interest in combating the fully developed ravages of peripheral vascular diseases. Neither the public nor the medical profession is satisfied with amputation as the sole therapeutic effort. Waiting for the time to amputate and then deciding at what level to do it is not conducive to the development of preventive measures.

Much progress has been made in the treatment of the acute phases of the peripheral vascular diseases; notably the most meticulous care of wounds, infections and gangrenous areas; rest; proper level of the affected extremity; hypodermoclysis with large quantities of Ringer's solution daily; intraduodenal administration of large amounts of hypertonic salt solution; intravenous administration of sodium citrate solution; constrictive hyperemia; intravenous administration of sodium iodide or calcium chloride; the use of typhoid vaccine and other forms of foreign protein therapy; thermopyrexia; the use of vasodilating drugs; the ligation of the femoral vein; periarterial sympathectomy and sympathetic ganglionectomy; ligation or excision of the femoral artery and paralysis of the peripheral sensory nerves.

Comment on two of these procedures is pertinent. The importance of keeping a resting extremity in the position which will secure for it the maximum circulation cannot be overstressed. The elevation of extremities as an essential part of the therapy has undoubtedly been responsible for a large number of amputations. This practice is a glaring example of unbelievable blindness to an universal instinct of patients, who not only refuse to keep the extremity elevated but often alternately hang it over the side of the bed and put it back. We have previously stressed the great dangers of resting the extremity in an elevated position, these have been confirmed by calorimetric studies.

Air superheated beyond the level of the body temperature has recently been shown by Freeman to be actually harmful. We have been under the impression for some time that the electrically heated cradles increased the pain and the progression of gangrenous extremities. Freeman has shown that excessive temperature makes the tissues call on the circulation for greatly increased metabolic processes. It is obvious that the blood which reaches an affected extremity should be effective and oxygen carrying as long as possible. We are using flannel or large wool lined stockings heated to just above average skin temperature before being applied. Definite harm results from a fluctuating environmental temperature about affected extremities. A draft of cold air over a leg in a critical phase from arterial disease will cause immediate blanching of the skin. The doors and windows should be closed before exposing affected extremities for dressings, studies, or treatments. It is desirable to keep the environmental temperature as nearly that of the skin as possible during the acute phases of peripheral vascular diseases. Our problems in this field of work in the winter as compared with those in the summer time illustrate the importance of the effect of subnormal environmental temperatures. It therefore appears desirable to keep patients with threatened or actual gangrene in rooms in which the temperature approaches that of the skin. Certainly wide fluctuations of environmental temperature either above or below that of the normal body (surface) temperatures should be avoided. Of the other measures mentioned many need no discussion. Some are of obvious value; the efficacy of others must be determined. The importance of some depends upon more or less specific problems with which one is confronted.

While the use of extreme degrees of heat, as caused by the electrically heated cradles, has been disapproved of in this paper it should be stated that the use of cold air to produce the passive vascular exercises may be harmful because of the vasospasm which it produces. This difficulty has been obviated by the use of air preheated to a level slightly above body temperature (102-105 degrees Fahrenheit).

A working classification is desirable but one should not classify his cases too rigidly as any long-standing case will usually exhibit some of the characteristics of two or more of the various types of peripheral vascular diseases. What was in the beginning a true case of Raynaud's disease may show later organic obliteration of many peripheral vessels due to thrombosis and fibrosis. An arteriosclerotic case may develop a sudden occlusion of various vessels due to thrombosis or arterial embolism. Any case of primary organic disease which develops a sudden critical period such as may be brought on by thrombosis, embolism, rupture of a vessel, injury, exposure to cold, *etc.*, always exhibits an element of vasospasm which may be temporary but still a very vital factor during the period when gangrene is so likely to develop (Table I).

TABLE I

CLASSIFICATION OF PERIPHERAL VASCULAR DISEASES

(A) *Primary Vasomotor Disturbances*

a. Vasoconstrictor disturbances

- (1) Raynaud's disease
- (2) Acrocyanosis (acro-asphyxia chronica; acroparesthesia; sclerodactylia)
- b. Vasodilatory disturbances
 - (1) Erythromelalgia
 - (2) Acute painful osteoporosis (?)
- (B) *Primary Organic Diseases of the Arteries**
 - a. Traumatic (chemical and thermal)
 - (1) Embolism and simple thrombosis
 - (2) Arteriovenous aneurysm
 - (3) Phenol and all caustics
 - (4) Frost bite
 - b. Inflammatory (toxic)
 - (1) Thrombo-angiitis obliterans
 - (2) Specific arteritis (syphilis, tuberculosis, peri-arteritis nodosa pyogenic)
 - (3) Nonspecific arteritis (exanthemata, typhus, typhoid, pneumonia)
 - (4) Nonspecific arteritis (chronic toxemia, ergotism)
 - (5) Endarteritis obliterans (cause undetermined)
 - c. Degenerative changes
 - (1) Arteriosclerosis (senile, diabetic and Mönckeberg)

We have made extensive use of intermittent *negative* and *positive* environmental pressures (Passive Vascular Exercises) in the treatment of the acute pain and threatened or actual gangrene due to peripheral vascular diseases. These exercises have been used in conjunction with other general measures which are appended.

GENERAL DIRECTIONS FOR HOME CARE OF THE FEET

Ambulatory Treatment

1. Wash feet each night with neutral (face) soap and warm water.
2. Dry feet with a clean soft rag without rubbing the skin.
3. Apply rubbing alcohol (70 per cent) and allow the feet to dry thoroughly, then apply a liberal amount of vaseline or toilet lanolin and gently massage the skin of the feet.
4. Always keep your feet warm. Use woolen socks or wool lined shoes in the winter and white cotton socks in warm weather. Use a clean pair of socks each day.
5. Use loose fitting bed socks instead of hot water bottles, electric heaters or any other form of mechanical heating devices.
6. Wear properly fitting shoes and be particularly careful that they are not too tight. Use shoes made of soft leather and without box toes.
7. Cut your toe-nails only in very good light and only after your feet have been cleansed thoroughly. Cut the toe-nails straight across.
8. Do not cut your corns or calluses.
9. Do not wear circular garters.
10. Do not sit with your legs crossed.
11. Do not use strong antiseptic drugs on your feet. Particularly never use tincture of iodine, lysol, cresol or carbolic acid.
12. Go to your doctor at the first signs of a blister, infection of the toes, ingrowing toenail or trouble with bunions, corns or calluses.
13. Drink at least four quarts of water each day.
14. Eat plenty of green vegetables and fruit in an otherwise well-balanced, liberal diet, unless you have been ordered to follow some special regimen.

* Vasospasm may occasionally play a constant part in the picture of the obliterative diseases; it always plays a temporary but very important part during the sudden critical periods of all vascular diseases.

15. Do not use tobacco in any form.
16. Have some member of your family examine your feet at least once each week.
17. Carry out your exercises prescribed by your doctor exactly as you were taught to do them in the clinic. Do them regularly and faithfully.
18. Come to the clinic for Passive Vascular Exercise treatments as directed.

HOSPITAL ROUTINE FOR PATIENTS WITH PERIPHERAL VASCULAR DISTURBANCES

1. Bed should be fitted with a Balkan frame with hand grips to aid patients in carrying out exercises and permit patients to move around in bed easily.
 2. Affected extremity or extremities should be placed on a pillow in the position which affords optimum circulation to the part. Heels should extend over the edge of the pillow to prevent excessive pressure from the mattress.
Position of optimum circulation as determined in the Vascular Clinic,
- (A) Right foot,
- (a) Recumbent position.....
 - (b) Sitting position.....
- (B) Left foot,
- (a) Recumbent position.....
 - (b) Sitting position.....
3. Large, doubly insulated cradle over the legs and feet, when necessary to relieve pressure of bed covers. Cradle should *not* be fitted with electric bulbs or other mechanical heating device, but the legs kept warm with large woolen or flannel stockings, or by keeping the room warm.
 4. Well-balanced, liberal diet.
 5. Drink at least four quarts of water each day.
 6. Patients should abstain from the use of tobacco in any form.
 7. Daily cleansing of the feet. Careful application of neutral (face) soap and warm water followed by alcohol (70 per cent). Dry feet without friction. Apply vaseline or bland oils to roughened or irritated areas. Special care should be given to the toe-nails and thick calluses.
 8. Ulcerated areas on the extremities should be specially treated.
 9. Use only non-habit forming drugs for the relief of pain in the extremities.
 10. Postural treatments as advised by Buerger and modified by Allen should be carried out as directed.
 11. Passive Vascular Exercise treatments as directed.
 12. All diabetic patients are simultaneously under the care of the Medical and the Surgical Services.
 13. The temperature of the patient's room should be kept at 80° F. or slightly higher and no fluctuations of this temperature should be permitted during examinations, treatments or dressings.
 14. All important clinical studies on the patients with peripheral vascular disturbances should be made in the Vascular Clinic of the Dispensary.

The effect of decreased atmospheric pressure upon the peripheral circulation has long been known. The fundamental idea of applying alternately *negative* and *positive* pressure to an extremity to increase the arterial circulation was expounded and put into actual clinical practice more than 50 years ago by Edgar Bluck, of Hamstead, England. In July, 1932, Dr. Louis G. Herrmann designed and built the original "Pavaex" units used to establish this method in our clinic and soon presented evidence that it was a valuable adjunct to conservative methods which we have advocated for many years.

The mechanical part of the apparatus has been modified and improved and studies made of the effect of various alterations of the curve of pressure changes and its actual influence upon the circulation of the extremity.

We found that approximately 80 Mm. *negative* and about 20 Mm. *positive* pressure with an alternation rate of two to four cycles each minute brought about the greatest increase in the arterial circulation and caused the least damage to the intimal lining of the arteries, in patients with organic changes in the peripheral arteries. Elevation of the foot several inches above the level of the heart was found to be more satisfactory than the use of larger amounts of *positive* pressure to free the extremity of venous blood. Certain variations of these pressures have frequently been necessary as, for example, when treating the cyanotic or static type of peripheral vascular disturbance which is associated with extensive arteriosclerosis, it has been found advisable to decrease the amount of *negative* pressure to about 60 Mm. and to increase the *positive* pressure to about 40 Mm.

The frequency or length of the "Pavaex" treatments must depend entirely upon the urgency of the condition which is being treated. Acute arterial occlusion either by operation, thrombosis, trauma or embolism must be considered as a surgical emergency and the "Pavaex" treatments must be given as often as necessary to keep the extremity alive until an adequate collateral circulation has become established. The number of hours of actual "Pavaex" treatment varies from four to eight hours each day, while the less urgent and ambulatory patients receive from seven to 15 hours of "Pavaex" treatment each week.

We would like to recite some of our observations with "Pavaex" therapy and present our ideas concerning the usefulness of this therapeutic adjunct to the treatment of various types of peripheral vascular disorders. The most startling results have been obtained among those patients who were suffering from a more or less sudden occlusion of the major arterial pathways to an extremity. There are also the patients in which temporary vasospasm of varying degrees plays such an important rôle in the ultimate outcome of the conditions; well illustrated by the ivory-like skin in certain cases of embolism, sudden thrombosis, ligation or rupture of a main artery in relatively young people when we know the collateral vessels are adequate if only they could be made to function. Further definite proof can be found in the reports of "Stupeur Arterielle" during the World War, the work of Leriche and the more recent report by Oughterson of the relief of this sudden vasospasm by immediate lumbar sympathetic ganglionectomy.

Our experiences in treating these acute crises of peripheral vascular accidents have been for us the most thrilling observations in our clinic for many years. In every instance of acute major arterial obliteration in which there has not occurred obvious death of tissues we have been able to relieve the spasm and draw blood into the extremity in an astonishingly short time with quick relief of pain and the prevention of gangrene. This has been accomplished even when sensation in the extremity has been absent or markedly diminished. When "Pavaex" treatments were started a striking case was that

of a woman 37 years of age with transient auricular fibrillation associated with mitral stenosis. Treatments were begun five hours after an embolus had lodged at the bifurcation of the right common iliac artery. The pain in her leg, which was agonizing and not relieved by large doses of morphia, was completely relieved within 15 minutes by passive vascular exercises and the color of the leg was changed from an ivory white to that of an active hyperemia. After a few days another embolus lodged in the left popliteal artery and the subsequent circulatory deficiency in the leg was relieved in less than five minutes. During the next two weeks the "Pavaex" treatments which at first were given at intervals of 60 minutes for periods of 30 minutes were gradually diminished in frequency until only five treatments of one hour were given each day. Three weeks after the first accident all treatments were discontinued and she has continued to be well since February, 1934. Pedal pulses have returned in the left foot but there is no palpable pulse in the entire right thigh or leg. The arterial circulation is adequate in both lower extremities. Operative procedures of either embolectomy or lumbar gangliectomy have been avoided. The dangers of subsequent thrombosis and continued neurocirculatory imbalance would certainly have continued after embolectomy. This case is typical of many other experiences we have had with cases of arterial embolism, peripheral aneurysms and sudden traumatic interruption of the major arteries.

The value of "Pavaex" therapy diminishes as we approach the other extreme of peripheral vascular disturbances where occlusion of the arterioles occurs unassociated with sudden increases in the pathologic process and consequently uncomplicated by vasospasm or neurocirculatory imbalances. In some conditions there seems to be a condition of vasoparalysis as contrasted with vasospasm. In such cases the foot and toes usually remain congested, red or cyanotic in nearly all positions with respect to the level of the heart and usually there is great pain. The picture is frequently complicated by serious disturbances in the veins. The primary and secondary arteries may or may not be occluded. Often the posterior tibial pulse is palpable and oscillometric readings may show evidence of some arterial circulation. In such cases the value of "Pavaex" treatments is not established and may rank as secondary in importance to the general procedures which have been outlined, if, indeed, not actually harmful.

There are all stages of progression of peripheral vascular diseases. Whenever the occlusive or thrombotic arterial processes outbalance the ability of the collateral vessels to furnish adequate arterial blood and also upset the normal, delicately adjusted vasomotor mechanism, then we have minor or major crises in which "Pavaex" therapy forms a most valuable adjunct. To be more specific, such conditions usually are present in cases of intermittent claudication together with other types of pain associated with rapid blanching of an elevated extremity. The main factor which frequently disturbs the circulatory balance after slow arterial occlusion is cold, which disturbs the normal vasomotor balance and prevents an adequate adjustment of the circulation.

The use of "Pavaex" therapy in the presence of open ulcers, acute infection or gangrene, calls for definite judgment. An old principle usually attributed to Larry specifies rest and nontraumatization as being very beneficial in the healing of wounds and in combating infections. It is obviously inadvisable to apply the massage by strong *negative* and *positive* pressures to acutely inflamed tissues. It is impossible to make a definite statement as to when it is safe to use it in connection with these various complications of peripheral vascular diseases. Common sense judgment must, to a large extent, be relied upon. In the presence of dry gangrene without obvious infection and without active migratory phlebitis we do not hesitate to employ it nor do we hesitate to use it in the presence of open superficial wounds provided the pressures are so regulated that they do not cause bleeding of the granulating tissue. With these precautions we have not yet encountered any trouble from the lighting up or the spreading of infective processes in a very large series of patients who have received active treatment.

True thrombo-angiitis obliterans is a condition diagnosed about ten times as often as it actually occurs. Because of the obvious inflammatory nature of the disease, involving not only the arteries but the veins and nerves, we have had our difficulties both with regard to selection of pressures as well as the length of time of application of the "Pavaex" therapy. When there is acute superficial migratory phlebitis or intense rest pain out of proportion to what one can see, the inflammatory process appears to be so active that "Pavaex" therapy may do harm. The spreading inflammation and the vasomotor imbalance are indicated by the intense pain and the remarkably rapid play of skin colors when the foot is subjected to changes of temperature or to alterations of position with respect to the level of the heart. In the quiescent phases of this disease when the intense rest pain is gone and the thrombo-inflammatory processes apparently inactive, the addition of "Pavaex" therapy has been beneficial. When the sufferers from this disease are fortunate enough to reach the stage of complete healing of the thrombo-inflammatory processes, nearly always accompanied by complete obliteration of the major arterial vessels, they are usually on pretty safe ground and get along comfortably with the continued observance of the great care learned by experience during their long siege of suffering. However, these so called healed or stationary cases may be handicapped in their work and exercise from intermittent claudication and foot pains. In such cases the use of "Pavaex" therapy has been very beneficial but even then we have employed caution in the degrees of pressures used, lest the inflammatory processes be lighted up.

The great problem with patients in the acute or threatening stages of thrombo-angiitis obliterans is to get them to realize the seriousness of the disease and to adjust their lives to the loss of one or more years devoted entirely to the business of trying to get the inflammatory processes healed and a comfortable circulatory balance established. This attitude toward the problem would greatly enhance our results and would undoubtedly lessen the

so frequent extension of the thrombo-angiitic process to cardiac and other visceral vessels.

In patients with peripheral arteriosclerosis associated with diabetic mellitus in which we so frequently see ulcerations, infections and gangrenous toes, the arteriolar bed is usually fairly good and "Pavaex" therapy has enabled us to establish an adequate circulatory balance. It, of course, must be used with great discretion and absolute willingness to vary the amounts of pressure as indicated by the condition of the foot. When there is dry gangrene, with no active inflammation, pressures of 80 Mm. *negative* and 20 Mm. *positive* are generally used. If there is a little more active inflammation we may begin with a *negative* pressure of 60 Mm. with no *positive* pressure; depending on elevation of the extremity, during treatments, for aid in the return of the venous blood. When there is definite venous engorgement, without acute spreading inflammation, we sometimes use *positive* pressures of as much as 30 to 40 Mm. To state the problem as a general principle—nobody will deny the benefit derived from active hyperemia in combating inflammatory processes, nor the harm of active massage in such processes. Procedures of therapy often put these two principles into antagonistic action and one has to decide at what point one must stop in order to secure the maximum benefit to the patient. An analogy of these antagonistic forces is seen in the treatment of an infected hand, in that one does not usually continue absolute rest throughout treatment at the expense of a functionless hand in order to avoid the danger of spreading the infection from manipulating the fingers. Active hyperemia of passive vascular exercises has been used in a large series of such cases and we feel it has been of immeasurable aid in combating all forms of gangrene, as well as ulcerations, or low-grade infections. Among these disturbances we have had many of our most striking results, associated with a quick healing of wounds and a rapid demarcation of the gangrene.

With a prolonged use of over 100 Mm. *negative* pressure, we have produced petechiae in the skin and have observed actual rupture of intimal surfaces of the smaller blood vessels. The average *negative* pressure should be approximately 80 Mm. There are a few theoretical dangers associated with the use of Passive Vascular Exercise therapy but with reasonable judgment it has proved to be a very safe and efficient addition to the therapy of peripheral vascular diseases, in an experience of more than 16,000 hours of treatment, to over 300 patients with obliterative arterial diseases of the extremities.

ARTERIAL SPASM IN THE EXTREMITIES*

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THE element of spasm in peripheral arterial disease has long been known, but its importance only recently recognized. All of the most careful students of the circulation have realized that a purely mechanical explanation of it was inadequate. Thus Harvey, in his dissertation "*De Motu Cordis et Sanguinis*," definitely links the force of the heart beat with the ability of the peripheral vessels to change their caliber as the two factors controlling the circulation. In another place he expresses this idea in a very specific form¹ as follows: "It is manifested that the blood in its course does not pass with the same celerity, neither with the same force in the same places and at all times. . . . In fear and under a sense of infamy and shame the face is pale, but the ears burn as if for the evil they heard or were to hear." To John Hunter² we are indebted for the first proof of contractility in the arteries. He not only demonstrated this property, but, by measuring the relative proportions of contractility and elasticity in the various arteries, he established the significant fact that the small arteries chiefly possess this ability of regulating by their contraction the amount of blood going to the regions they supply, while changes in the caliber in the larger arteries are principally due to elasticity. We can but marvel at the accuracy of these deductions based upon experiments aided only by the simplest of instruments and carried out before the time of the Revolutionary War, fifty years before the histologic proof by Henle that smooth muscle fibers were present in the arterial walls. The presence of nerve filaments extending to the arteries was an anatomic fact of indefinite antiquity even in the eighteenth century, and their action in constricting the arteries was considered a necessary hypothesis. Only its actual demonstration was lacking, as is well illustrated by Haller's³ statement in summarizing his extensive experiments. "The sudden changes produced in the circulation by the mind, the erection of the penis, of the clitoris, of the nipples of the breast; the changes of color in the cheeks; cold and heat, tremors, inflammations, obstructions, the strong motions which violent pains or wound of the nerves often occasion. All these facts considered render very probable the action of the nerves on the arteries; since it, by this, appears that they have certainly a great power, either of retarding or accelerating the circulation. But I have never been able by any experiment to find, by observation, that irritating the nerves created any change in the velocity of the humours contained in the vessels of the circulation. I have indeed observed once or twice that by irritating the nerves it revived the action

* Read before the New York Surgical Society, November 14, 1934.

of the blood and restored the motion of it in arteries that were cut which had ceased to supply any. But I have had great reason to attribute this effect to some mechanical action." Such was the situation for another century until within the same decade epochal discoveries were made in the physiologic and in the pathologic fields. Claude Bernard⁴ demonstrated the vasomotor control by sympathetic nerves over the peripheral circulation in 1851. In 1858, Brown-Sequard⁵ made the following deduction: "In those cases of gangrene in which no obstruction has been found after death in the vessels of the dead parts, it is extremely probable that a long persistent spasm of the blood vessels has existed." Four years later Raynaud,⁶ in his classic monograph on local asphyxia and symmetrical gangrene in the extremities, clearly showed that spasm could lead to gangrene. From this time we have known of arterial spasm as the cause of a relatively uncommon condition bearing Raynaud's name. But until recent years we have, aside from this, practically ignored it clinically. With the reawakening of our interest in the sympathetic nervous system since the war, methods for the clinical study of vasomotor phenomena have been developed. The data obtained have necessitated a complete revision of our conception of the peripheral circulation merely as a mechanical hydraulic system. In addition to its occurrence in Raynaud's disease, arterial spasm is often a critical factor in the common organic arterial diseases. It is a frequent accompaniment of nerve irritation whether in the peripheral nerves or in the central nervous system, and it is an important sequel of trauma.

SPASM IN ORGANIC VASCULAR DISEASE

When one of the main arteries in the extremity is occluded by organic disease, the effect on the local circulation varies enormously. It has long been common knowledge that you may have complete obliteration of pulsation in one or even both of the major arteries of the foot without impairing the viability of the part or even without causing any very noticeable symptoms. In such a case the condition of two classes of vessels becomes of paramount importance; namely, the collateral circulation and the smaller terminal arteries. In advanced noninflammatory occlusive disease such as that typically seen in arteriosclerosis occlusiva, either senile or diabetic, it can easily be demonstrated that associated with the circulatory deficiency there has been an inhibition of vasoconstrictor tonus. If the vasomotor nerves to the part are temporarily paralyzed by spinal, general or local anesthesia in such a case, there is no improvement in the circulation. Nature apparently has provided some method under these circumstances of overcoming even the physiologic degree of vasoconstriction.⁷ On the other hand, in many instances of inflammatory or irritative lesions of the arteries, it is possible to demonstrate a striking improvement in the deficient circulation when the sympathetic innervation is temporarily or permanently abolished.⁸ Arterial spasm in such instances often does play the determining rôle in making a reduced circulation insufficient to maintain the viability of the part.

We believe the explanation for this can be deduced from the nature of the pathologic lesion in the two instances. In arteriosclerosis occlusiva the process is primarily a degenerative one and is limited to the intima and media of the vessels. In thrombo-angiitis obliterans, on the other hand, there is an inflammatory reaction extending through the wall of the vessel. In fact, this is often so marked that the vein, artery and accompanying nerve trunks are glued together in one mass by it. The irritation of sensory sympathetic nerve fibers is probably the point of origin for the afferent impulses which cause the marked vasoconstrictor reflex. The motor impulses then cause a constriction in the diseased vessels from which the reflex arose, a result of no great importance, but they also cause a constriction of the anastomotic and terminal arteries on which the viability of the extremity distal to the arterial obstruction depends. This is the serious element about vasoconstrictor spasm associated with an organic disease of the arteries. It is probably true that recent embolism or rapid thrombosis usually evokes a similarly irritative vasoconstriction of the collateral circulation.

The recognition of this element of spasm in organic arterial disease is of great importance as its eradication enables us to improve the collateral circulation. The best method of accomplishing this is still somewhat in doubt. Peri-arterial sympathectomy does not permanently eradicate such spasm. Lumbar ganglionectomy does do so but is a major operative procedure. The injection of foreign protein and other fever-producing drugs will result in vasodilatation for a few days but are definitely contra-indicated in patients with any degree of arteriosclerosis, on account of the danger of thrombosis. We have been very hopeful that the method of passive vascular exercise as outlined by Doctor Reid would materially assist in overcoming such spasm just as the muscle spasm about an inflamed joint can be gradually overcome by extension. Possibly the addition of a vasodilating stimulation by warming the blood in the simple method devised by Landis and Gibbon⁹ during the time the alternate suction and pressure is being applied to the involved extremity may further assist in this regard. In the common organic peripheral arterial diseases it is chiefly in thrombo-angiitis obliterans that continued spasm plays a particularly significant rôle and we wonder whether the added load put upon the vessel whose walls are involved in the inflammatory reaction would tend to light up the active phase of the disease. None of the vasodilating drugs that have yet been used has succeeded in producing a lasting obliteration of this vascular spasm. Up to the present we still feel that lumbar ganglionectomy in carefully selected cases offers these patients the most complete and lasting vasodilatation of the collateral circulation. In brief, then, the treatment of arterial spasm superimposed upon organic vascular disease still has to be individualized for each case.

RAYNAUD'S DISEASE

The classic example of arterial spasm is that seen in Raynaud's disease. The paroxysmal nature of the attacks in the absence of evidence of organic

arterial disease makes the diagnosis of the outspoken cases of this malady relatively simple if no cause for vasomotor irritation can be found. Usually attacks can be initiated by immersion of the hands in cold water. Women are predominately the sufferers of this disease. From the time of Raynaud's original description, the theory of increased vasomotor activity had not been seriously questioned in the etiology of this condition until recent studies of Lewis and his coworkers.¹⁰ He advanced the theory of a local fault in the periphery independent of vasomotor innervation. Certain it is that psychic and reflex stimuli can induce true attacks of the disease. On the other hand, there are apparently typical cases in which the angiospasm is not fully released by temporary paralysis of the vasomotor nerves but is abolished by heat. Quite possibly these divergent views in regard to the underlying mechanism can be partially harmonized by the recent discovery of Smithwick, Freeman and White.¹¹ They found that small amounts of adrenalin produced an attack of angiospasm in the extremities of patients with Raynaud's disease even after complete sympathetic denervation. Possibly, then, the local fault of Lewis may be a hypersensitivity to circulating adrenalin in these patients. We have not seen any patient with what appeared to be uncomplicated Raynaud's disease whose angiospasm was not at least diminished by a temporary or permanent paralysis of the vasomotor innervation. In regard to treatment, most of the cases of Raynaud's disease that we see in our clinic are not sufficiently severe to warrant urging a major operation. They are inconvenienced by the attacks but when they protect themselves from the cold they can carry on a fairly normal life. If such a person can move to a warm climate, we advise her to do so. In addition to such protection from cold, we use Kerr's method of treatment by recourse to the reflex hyperemia which follows hypercooling the extremity.¹² When this is insufficient, or if the sensory acuity or the nutrition of the fingertips is threatened, then we advise dorsal ganglionectomy after proving that temporary denervation improves the circulation.

When one becomes interested in spastic arterial disease, he finds a great number of individuals who have minor degrees of angiospasm in the hands, almost exclusively in women. In these individuals, the degree of vasoconstriction in the upper extremity may be as marked or even more so than in the lower extremity. The milder examples of this type merely show such an accentuation of the vasomotor gradient in the hand (CHART I). From this, however, there are all gradations up to true ischemic attacks in one or more fingers which have been described under the term "dead fingers." Just what the relationship of these more numerous lesser degrees of angiospasm is to true Raynaud's disease is uncertain. There is no evidence to suggest that these individuals are likely to develop a severe form of Raynaud's disease, but there is no line that can be drawn to separate their condition from the more pronounced syndrome.

ANGIOSPASM SECONDARY TO FUNCTIONAL AND ORGANIC NERVOUS DISORDERS

Anyone who has treated a considerable number of cases of old poliomyelitis will recall the usual coolness and blueness of the foot on the involved side at a moderately cool room temperature. This is a form of increased vasoconstrictor tonus as compared with the normal side and is not due to organic arterial disease as can easily be demonstrated by a temporary vasomotor paralysis. We have found that many organic diseases of the central nervous system associated with irritation or scar tissue formation may have an outstanding vasomotor component. We have seen this phenomenon also as a localized condition in functional nervous disorders. Irritation of the periph-

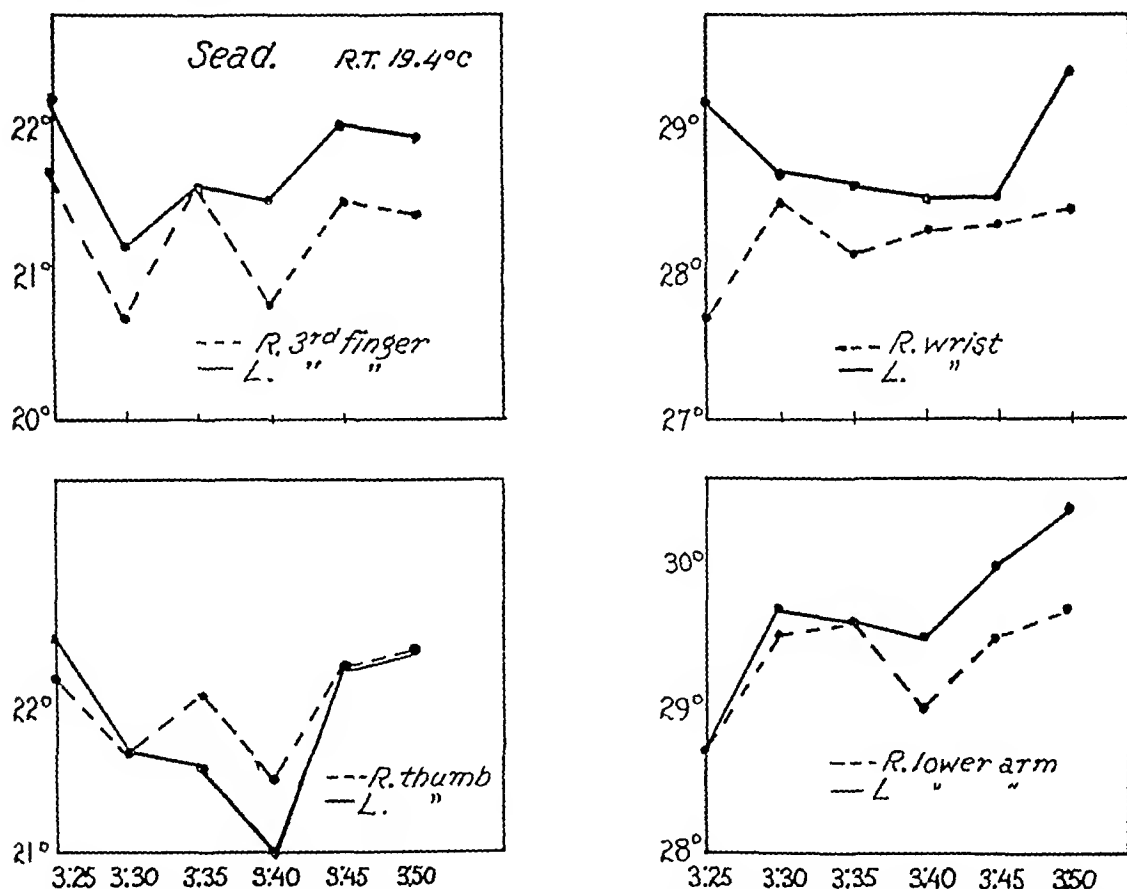


CHART 1.—Temperature readings of an exaggerated vasomotor gradient in the upper extremities in a patient without other evidence of vascular disease. Note the extremely low temperatures of the fingertips. This patient had always known that her hands were colder than those of most people. No evidence, however, of attacks resembling Raynaud's disease.

eral nerves or their roots such as is found with cervical rib, causalgia, or neuroma formation may be associated with marked angiospasm.

The following recent case is an excellent example of vasomotor neurosis of this type.

CASE REPORT

H. W., No. 94126, female, aged 45. Fifteen months ago this patient first noted vague numbness and tingling of the right hand which disappeared in a few days. She had a similar attack of short duration six months ago. Three weeks ago she began having intense numbness and tingling of the whole right hand extending up in an irregular fashion on to the wrist. Associated with this she had noted that the hand became bluish and at other times pale. With the attack she had pain in the hand. Recently she had noted

some pain in the right shoulder also. Her right hand had become extremely sensitive to cold, and heat relieved the numbness and pain. For the last ten days she had had to get up several times during each night on account of these symptoms, putting her hands into warm water, which promptly relieved the pain. Also at times during the day she had kept the hand wrapped in flannel.

Past History immaterial as far as the present illness is concerned.

Physical Examination.—Right hand paler and cooler than the left; radial and ulnar pulses good on both sides. Tenderness over the right seventh cervical transverse process. Hypoesthesia on the palmar surface of the right hand and fingers; hyperesthetic area in



FIG 1—H. W. Roentgenogram of cervical region shows a hypertrophic spine situated at the tip of the right seventh transverse process extending forward, its shadow extending under that of the first rib. The lower borders of both seventh cervical transverse processes have been outlined with pencil on the film.

the right thumb and wrist. Also area of hyperesthesia over the right shoulder and right antecubital fossa. Weakness on movements of the right hand and to a lesser extent of the right forearm. Immersing the hands in cold water at 15° C. shows marked sensitiveness of the right hand and causes some color changes. Recovery of the hands, however, from the cold bath is at approximately the same rate. Exposure of the right hand to cold water produces the same symptoms as the patient's attacks.

A radiograph showed a hypertrophic spine extending forward from the tip of the right transverse process. It is exactly at this point that the patient experienced pain (Fig. 1).

ARTERIAL SPASM IN THE EXTREMITIES

Preoperative Diagnosis.—Vasomotor neurosis due to pressure on the brachial plexus of an elongated right seventh transverse process.

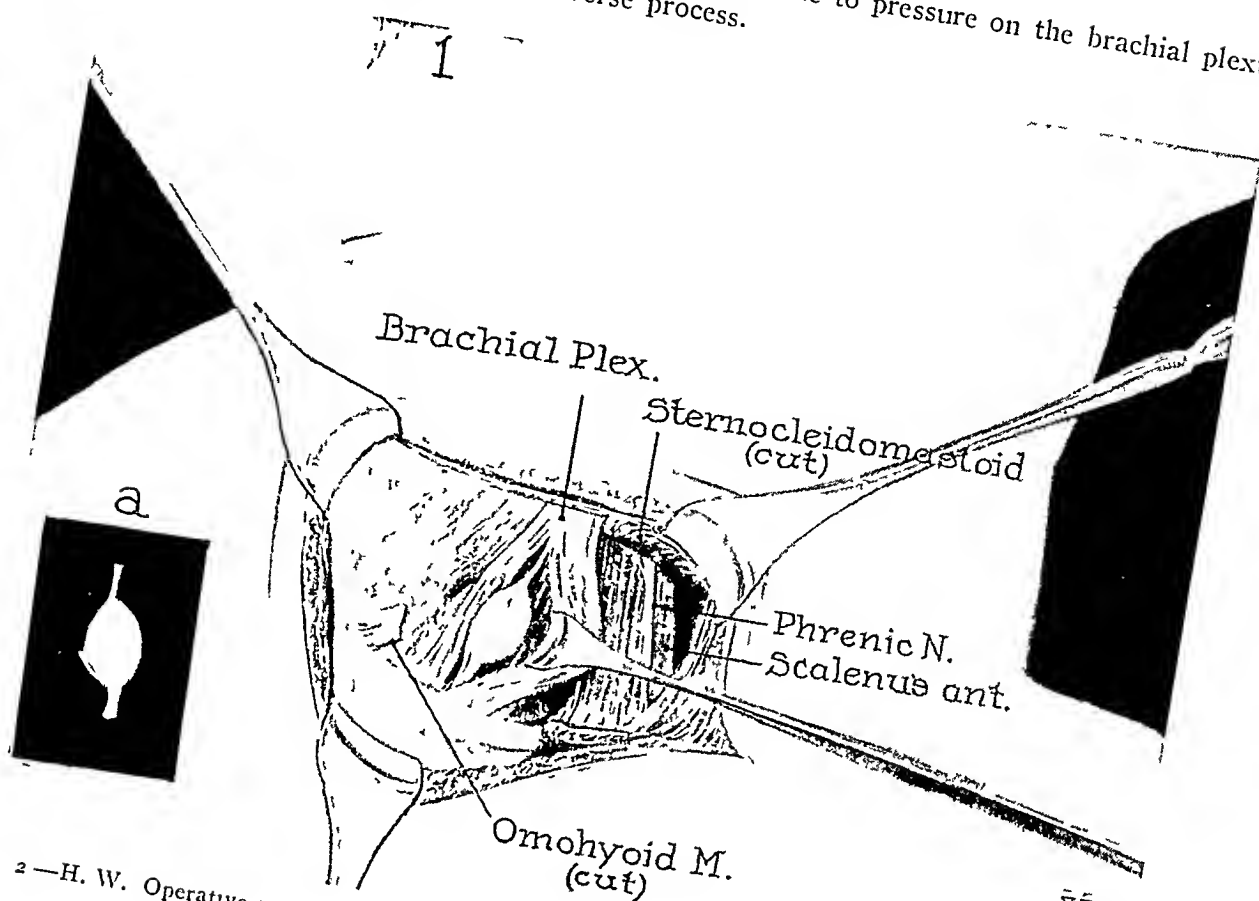


FIG 2—H. W. Operative exposure of neuroma on the posterior cord of the brachial plexus (a) Neuroma after excision

Operation.—On exploration of the region through an anterior approach it was found that the transverse process lifted the scalenus medius muscle directly under the brachial plexus. On one of the posterior cords of the plexus an elliptical mass was felt directly over

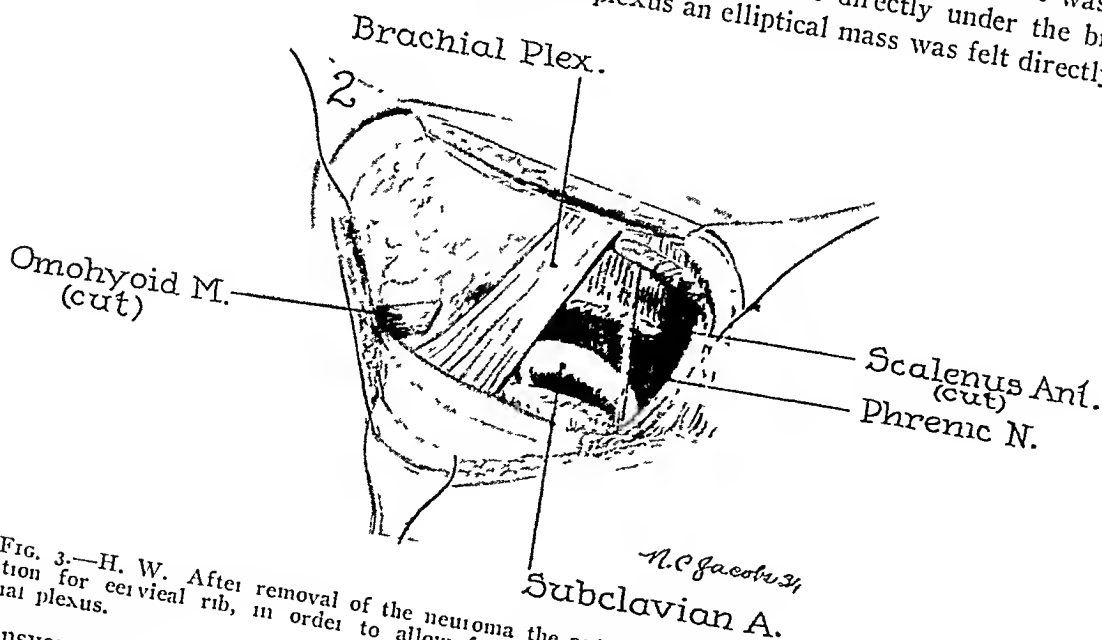


FIG. 3.—H. W. After removal of the neuroma the anterior scalene muscle is divided as in the operation for cervical rib, in order to allow forward displacement of the subclavian artery and brachial plexus.

the transverse process. On gently separating the anterior cord of the brachial plexus, it was found that this mass was a neuroma of the brachial plexus (Fig. 2). This neuroma

was removed (Fig. 2a). The scalenus anterior muscle and fascia were divided (Fig. 3) in order to allow the forward displacement of the plexus and subclavian artery. The transverse process was not removed.

Postoperative Course.—The patient's symptoms were relieved at once. She has had no more attacks of tingling, numbness and no more pain in the right hand. She can now stand cold on the right hand without discomfort.

Final Diagnosis.—Vasomotor neurosis associated with a neuroma on a posterior cord of the brachial plexus apparently induced by irritation of this posterior cord by an elongated transverse process.

There are cases on record, for example, where the vasomotor irritation from a cervical rib has resulted in thrombosis of the radial and brachial arteries with maintenance of circulation in the subclavian and axillary arteries.¹³ Mechanical pressure effects can in such an instance be entirely excluded. The thrombosis and associated gangrene in one or more digits was due entirely to arterial spasm. This evidence together with that of a similar thrombosis resulting after long periods of frequent angiospastic attacks in Raynaud's disease provides conclusive proof, in my estimation, that continued spasm favors ultimate thrombosis in the spastic vessels, and argues strongly in favor of overcoming such spasm whether its presence results from peripheral nerve irritation, Raynaud's disease, or accompanies organic arterial disease. Aside from distant vascular effects associated with peripheral nerve irritation from pressure or scar tissue involvement, the vasomotor neuroses secondary to other nervous disorders do not ordinarily cause serious symptoms and rarely will require treatment for themselves.

ANGIOSPASM CONSECUTIVE TO TRAUMA

The association of vasomotor disturbances with the late effects of trauma furnishes a fascinating story. There are two main types. The first of these is paroxysmal angiospasm which closely resembles the symptomatology of a local Raynaud's condition with painful ischemic attacks, particularly on exposure to cold.¹⁴ The trauma may be many months in the past and unassociated with any gross scarring. Presumably this is a reflex phenomenon associated with scar tissue involvement of small nerves. We have not found evidence of general decalcification in this form of angiospasm and its treatment is similar to that of Raynaud's disease.

The other form of vasomotor disturbance resulting from trauma is called painful osteoporosis or reflex traumatic arthritis. Some will question the discussion of this interesting and important clinical syndrome among the angiospasm as there is definitely present, at least during certain stages, an increased vascularity about the inflamed joints. Leriche and his co-workers,^{15, 16} have ascribed the bone changes entirely to vasodilatation in the bones. However, vasodilatation achieved by removing the vasoconstrictor supply to the part over a period of years fails to produce such bone changes. Furthermore, together with the bone changes, there are usually outspoken evidences of arterial spasm in the cutaneous regions of the distal part of the foot. Consequently it seems to us fitting to consider this interesting sequel

of trauma with the angiospasm which frequently accompanies it. After an injury which may be single or multiple, serious or apparently quite trivial, the individual experiences a period of increasing pain causing disability. Exercise of the part quickly brings on extreme pain after the syndrome is well established. Frequently within a month of the development of symptoms, a marked osteoporosis in the region occurs. This usually differs strikingly from loss of calcium associated with mere disuse in that it gives an early extreme mottling of the bone. The joints usually involved are those of the tarsus or carpus. In the region of the involved joints there is a marked increased vascularity. Frequently there is also evidence of sympathetic stimulation such as excessive perspiration, coolness and clamminess of the anterior part of the extremity, *etc.* We are still in doubt about the exact cause of the bone changes and of the pain. But we know that both of these may remain with little improvement over intervals of several months or even years, although the ultimate result is usually some recalcification and diminution in pain. When the interval has been many months, it is often found that the cartilages between the small bones have been destroyed and ankylosis has occurred. Frequently at the height of the osteoporosis a diagnosis of tuberculous arthritis has been made and amputation has often been advised. However, careful analysis of the bone changes can usually differentiate fairly readily between these two conditions, the chief confusing factor being the protracted course of each. There is a true inflammatory reaction in the joint itself but an infectious etiology can be dismissed. Apparently the mechanism of the condition is on a vascular basis. Whether the signs of sympathetic stimulation and arterial spasm are due only to the pain which dominates the clinical picture or whether there is a true vasomotor imbalance with vasodilatation in certain areas as about the joints and vasoconstriction in others, such as distal cutaneous ones, is not known. We sorely need further elucidation concerning the mechanism of the vasomotor changes. In accordance with our uncertainty concerning the mechanism causing the syndrome, the treatment at present is empirical and its rationale is uncertain. However, the results in certain cases have been very gratifying. Leriche first advised periarterial sympathectomy. Although he and his school are still enthusiastic supporters of this form of treatment, it seems that even in their hands it has probably not proved thoroughly satisfactory as they have more recently resorted in a number of instances to ganglionectomy. It has been our experience that periarterial sympathectomy usually results in improvement but most frequently this improvement is only temporary. Sympathetic ganglionectomy we have felt to be more satisfactory and we have achieved temporary relief of pain by anesthetizing the lumbar sympathetic cord. In lesser degrees of the condition, conservatism is justifiable as usually such cases eventually recover fairly completely. If some simple conservative treatment would permanently relieve these cases it would be very useful.

I am convinced that some reflex disturbance in the blood supply of the involved part is a common accompaniment of trauma and that the study of such minor conditions will result in valuable information being obtained, and almost surely in a better understanding of this significant type of reaction. I would also like to suggest that this component of spasm which we have seen playing such an important rôle at times in organic peripheral disease, following trauma, and also as a complication of certain nervous disorders, may possibly prove equally important in certain of the chronic parenchymatous diseases. Here also, it may well pay us to consider not merely the structural changes but the functional condition in the local circulation.

CONCLUSIONS

The existence of arterial spasm has long been known to occur as a comparatively rare clinical entity. Its occurrence in the common arterial diseases of the extremities has only recently been studied. The extreme forms of angiospasm may undoubtedly lead to thrombosis and gangrene. Vasomotor disturbances following trauma present an interesting though complicated group of conditions which in their marked forms occur as striking clinical pictures and in their milder forms as frequent disturbances.

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INDICATIONS FOR AMPUTATION IN PROGRESSIVE ARTERIAL OBLITERATION OF THE LOWER EXTREMITIES*

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HOWEVER much we may dislike to amputate a limb for arterial deficiency, we must still accept the end-result of a process in which the rate of obliteration of arterial supply exceeds that of the development of collateral vessels, as amenable only to surgical removal. Moreover, an early understanding of the symptoms and physical signs which render a continuation of conservative treatment either unsafe or useless will not only return the patient to a state of physical and mental comfort but, in most cases, will relieve an economic burden which patient and hospital can ill afford to maintain.

The indications for and the level at which amputation should be done are not always clear cut. Increasing experience in the care of these patients within the hospital and a careful follow up study of results after treatment will to a striking degree clarify the indications for a given operation. This is particularly true in the group with senile gangrene and in the group of patients with gangrene associated with diabetes mellitus.

It is my privilege tonight to discuss that group of patients suffering from thrombo-angiitis obliterans, senile gangrene, and the so called diabetic gangrene, beginning at the point where conservative measures have failed. I shall try to outline as clearly as I can those indications for which we look in an effort to determine when and at what level amputation can be done.

By conservative measures, I include all procedures except amputation of a digit or limb. For the purpose of this discussion, then, an operative procedure as extensive as a lumbar ganglionectomy is included as falling within the realm of conservative measures. Without going into a detailed discussion of the various methods advocated for the care of these patients, it would seem necessary to briefly summarize the measures which have been found of practical importance to us in the treatment of these cases in the Peripheral Vascular Clinic at the Massachusetts General Hospital and in the Diabetic Clinic at the New England Deaconess Hospital. It is not the purpose of this paper to give reasons why certain procedures are or are not used by us. It would seem that we might render a more clear cut conception of these conditions as we see and treat them, if we avoid an academic discussion of the various methods advocated and present only an outline of the procedures which have seemed to us to be most useful and practical. From this background, we shall attempt to outline the findings from which we determine that conservative methods have failed or are not worthy of a trial. Let me

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point out that, although the management of the three groups of cases is similar, the indications for a major amputation and the factors involved in the selection of treatment in each group are distinctly different. The man whose experience has been largely confined to the treatment of thrombo-angiitis will have many disappointments and a high mortality in his early experience in the management of diabetic gangrene. Conversely, the man whose experience has been largely with diabetic gangrene may sacrifice an unnecessary number of extremities in the group of patients with thrombo-angiitis obliterans. I need not warn you that as our experience increases in the care of these patients, we more clearly visualize the course of the process in each individual case; a given foot which in our early experience might seem hopeless may later be recognized as amenable to a conservative operation.

RÉSUMÉ OF CONSERVATIVE MEASURES

It is the aim of all conservative procedures to: (1) control infection; (2) relieve pain; (3) stimulate the development of a collateral circulation (it is quite possible that the improvement which takes place in many of these patients is due to a readjustment of the circulatory needs of a given foot rather than to an actual increase in collateral vessels); and (4) release vasomotor spasm. These results we have tried to obtain by:

(1) Rest in bed with sufficient medication to control pain. It is important that the resting position of the involved foot is such that the foot is not blanched (Buerger's angle of circulatory sufficiency).

(2) Large hot packs of saturated boric solution used to control a spreading infection.

(3) Local applications of Dakin's solution during the day, occasionally Obtundia (Clapp's) for a painful ulceration, or a small amount of boric ointment at night. At the Deaconess Hospital, hexylresorcinol solution S T 37 (1-4) is used when a nonirritating moist dressing is desired.

(4) Careful hygiene of both feet; avoidance of pressure areas by placing a small pillow just above the heels; daily massage with hydrous lanolin, Balkan frame and, in diabetic patients, particular care to the back.

(5) Buerger's postural exercises¹ as modified by Allen² in all cases except those with evidence of lymphangitis or spreading infection.

(6) General supportive measures such as iron for anemia, a well-balanced diet, and a high fluid intake.

(7) Smoking is advised against. Since the appearance of Maddock and Collier's³ work, stringent efforts are made to prohibit the use of tobacco by patients with thrombo-angiitis obliterans; less attention is given to it in the arteriosclerotics with or without diabetes.

(8) Peripheral sensory nerve block, first suggested by Silbert⁴ and developed by Smithwick and White,⁵ is our most important agent in the management of the more painful lesions in the lower extremities of patients with thrombo-angiitis obliterans; it is of occasional benefit in arteriosclerotic gan-

grene, but is only rarely if ever indicated in the presence of diabetes mellitus. It not only gives complete relief from pain but combines with this the vasodilating effect of a sympathetic ganglionectomy.

(9) Protein shock⁶ using typhoid vaccine intravenously is much less frequently employed than in the past. It gives a temporary vasodilatation, is of value in the study of the vasomotor index;⁷ and in those cases without sufficient discomfort to warrant nerve block it shortens the hospital stay and at times is very helpful in obtaining a temporary vasodilatation in preparation for and following amputation of a digit. It is dangerous in arteriosclerotic and diabetic gangrene⁸ because of the possible thrombosis which may occur during the prodromal stage when the rate of blood flow is diminished. It may prove particularly valuable in a group of thrombo-angiitis obliterans patients when the upper extremities are involved.

(10) Sympathetic ganglionectomy has been done in only three of the 53 cases of thrombo-angiitis obliterans and in none of the cases of either senile or diabetic gangrene in this series.

(11) Alternate negative and positive pressures^{9, 10} ("Pavaex" treatment of Herrmann and Reid¹¹) have not been used over a sufficiently long period of time to have influenced the group of patients studied in this series.

METHOD OF EXAMINATION

We depend upon a careful clinical examination for the determination of the arterial supply to a given extremity. Both legs are bared to above the knees.

Inspection.—Rapid blanching on elevation and the slowly developing rubor or cyanosis when dependent is one of the most striking and constant findings of a poor arterial supply. The rapidity of blanching, the level to which the rubor extends, the presence or absence of atrophy of the calf or foot muscles, or of a puffy edematous appearance of the foot and toes are carefully noted. Migrating phlebitis, if present, is of great significance.

Palpation of the dorsalis pedis, anterior tibial, posterior tibial, popliteal and femoral arteries to determine the presence or absence of pulsation is of fundamental importance. Temperature variations to touch at the same level on the two sides and at different levels on the same side are important. Whether the foot is moist or dry may suggest the presence or absence of a vasomotor imbalance.

The *oscillometer* is occasionally used but has not been found to be of great clinical value to us.

Roentgenographic examination of the vessels to determine the presence or absence of calcification may be of value in differentiating between thrombo-angiitis obliterans and arteriosclerosis. It is of no value in determining the level at which amputation if necessary should be done.

Spinal anesthesia,¹² novocaine block of one or more peripheral sensory

*nervcs*¹³ or typhoid vaccine intravenously¹⁴ may be used to determine the degree of vasomotor spasm present.

THROMBO-ANGIITIS OBLITERANS

Diagnosis.—A diagnosis of thrombo-angiitis obliterans is made in a man, usually young (the average age at onset of 53 patients was 41 years), with symptoms of years' rather than months' duration, most frequently beginning as cramps in the calves of his legs, or a soreness in his arches after walking. Occasionally one sees a rapid, fulminating type of disease with a short history and rapidly spreading gangrene. On entrance to the hospital, there will usually be a painful open lesion on one or more toes of a swollen dusky foot with the usual signs of arterial insufficiency. The disease may involve all four extremities, nearly always involving the lower extremities first, usually one at a time. Migrating phlebitis, if present, is almost pathognomonic. Roentgenograms, except in the occasional patient where there is a superimposed arteriosclerosis, will be negative for calcium deposits in the arteries. Usually the vasomotor index is low but occasionally quite marked. Collateral circulation may be developed to an extraordinary degree.

Incidence of and Indications for Operation.—Most patients who seek hospital treatment for thrombo-angiitis obliterans have a painful open lesion. This usually involves one or more digits of a foot and as the disease progresses other extremities are involved. A high percentage of cases who come for hospital treatment will have had some type of amputation. Of 53 cases entering the Massachusetts General Hospital during the past seven years, 32 per cent have had a minor amputation and 26.4 per cent (Table I) have had an amputation of a lower extremity.

TABLE I

THE INCIDENCE OF MINOR AND MAJOR AMPUTATIONS IN THROMBO-ANGIITIS OBLITERANS, ARTERIOSCLEROTIC, AND DIABETIC GANGRENE

Diagnosis	Total Cases	No Op.	Minor Amp.	Major Amp.
Thrombo-angiitis obliterans.....	53	41.6%	32.0%	26.4%
Arteriosclerotic.....	55	36.4%	9.1%	54.5%
Diabetic.....	253	51.0%	2.7%	46.3%

In the management of these cases it is exceedingly important to recognize: (1) the marked tendency for the development of collateral circulation, and (2) the resistance which this group of patients has to the development of a septicemia or a rapidly progressive infection. This is in striking contrast to the deaths from septicemia or from local infections in any group of cases with gangrene and diabetes. In no instance have we had a death from septicemia in this group of patients, and in only four cases did a rapidly ascending infection or progressive gangrene necessitate a guillotine amputation.

The slowly progressive course of the disease, the frequent involvement of all extremities, together with the remarkable development of collateral circulation which occurs, make it safe and, we feel, important to avoid a major

amputation even at the expense of prolonged hospital treatment. For this reason, except in rare instances, a major amputation is not done without first attempting the removal of one or more digits and, if necessary, drainage of the deeper structures of the foot. Pain is no longer an indication for major amputation. Sensory nerve block with its accompanying vasodilatation and relief from pain has been the greatest single factor in lowering the incidence of major amputations. Smithwick and White¹⁵ report 25 cases with and without nerve block showing a drop of from 74 per cent to 30 per cent in the number of cases which come to a higher operation.

An early high operation may be necessary for (1) progressive extension of gangrene in spite of conservative measures; (2) rapidly ascending infection; and (3) destruction of so much of a foot that insufficient structures remain to insure adequate weight bearing should complete healing take place. The Gritti-Stokes amputation is the procedure of choice (Table II). Rarely is a higher amputation necessary. We do only an occasional amputation below the knee in these patients. When infection or gangrene is extending rapidly a guillotine amputation may be indicated. This is done below the knee if circulation will permit, otherwise above. In most cases when this operation has been done below the knee a closed amputation, usually a Gritti-Stokes, is advised as soon as the patient's general and local conditions will permit.

TABLE II
INCIDENCE OF AMPUTATIONS AT VARIOUS LEVELS

	T. A. O.	Arteriosclerotic	Diabetic
Total cases operated.....	31	35	124
Amputation of toe.....	54.9%	14.3%	5.6%
Guillotine.....	9.7%	8.6%	6.4%
Lower leg.....	6.4%	2.8%	12.1%
Gritti-Stokes.....	25.8%	22.8%	15.3%
Thigh.....	3.0%	51.4%	60.5%

ARTERIOSCLEROTIC GANGRENE

Diagnosis.—Arteriosclerotic gangrene is usually present in older people (the average age at onset of 55 patients was 65 years), affects both men and women, and in most cases one leg at a time. The upper extremities are rarely involved except by sudden massive thrombosis or an embolism. There is nearly always calcification of the vessels, very little vasomotor influence and only a fair tendency to develop collateral circulation. Calcification of the vessels of the foot and leg is usually demonstrable roentgenologically. There is a normal blood sugar.

Incidence of and Indications for Operation.—Patients with senile gangrene seek relief for three reasons: (1) an active lesion such as a small painful ulceration or slight infection around a nail; (2) gangrene of one or more toes; and (3) severe pain without any open lesion. Unless actual gangrene involving the deeper structures of a digit exists most patients respond to the hospital routine already outlined. Undoubtedly the early response

to treatment represents a readjustment of the circulatory needs of the extremity rather than a new development of collateral circulation. Many of these patients come to the hospital with severe, unbearable rest pain to become pain free within two weeks' time without treatment other than the simple measures previously described. Gradual rehabilitation by regular graded, active exercises, careful foot hygiene, and living within circulatory possibilities may postpone actual gangrene for years.

Amputation of a Toe.—In only five or 9.1 per cent of 55 cases of arteriosclerotic gangrene was amputation of a toe successfully accomplished (Tables I and II). It is usually safe and may be successful providing that there is no lymphangitis for: (1) osteomyelitis of a phalanx without actual gangrene; (2) localized gangrene of the tip of a digit if there is pulsation in the popliteal artery and no definite level of temperature or color change in the lower leg, providing the patient is not having severe pain after two weeks of hospital treatment; and (3) in the presence of good pulsation in the dorsalis pedis artery. Major amputation was done in 54.5 per cent of our 55 cases. It is usually indicated for: (1) severe pain with or without actual gangrene which is not controlled after three weeks of careful hospital treatment as outlined above; (2) gangrene of one or more digits without pulsation of the dorsalis pedis artery, with deep infection or lymphangitis not controlled by constant moist dressings; and (3) gangrene of all or a part of a digit with or without pulsation in the popliteal artery when there is a definite level of temperature or color change with the foot in the dependent position.

Amputation through the upper third of the lower leg may be safely and usually successfully done in a patient under 70 years of age who is in good general condition, and has good pulsation in the popliteal artery providing that the skin at the level of incision is in good condition and there is no temperature or color change, and no lymphangitis above the level of the ankle.

A Gritti-Stokes amputation commands about the same requirements as an amputation through the lower leg, except that good collateral circulation around the knee is of more advantage than pulsation of the main vessel. This would be shown by absence of pulsation in the popliteal artery and no temperature or color change above the ankle, when the foot is dependent. Neither a lower leg nor a Gritti-Stokes amputation should be done if the patient's general condition is poor and there is little likelihood of his using an artificial limb.

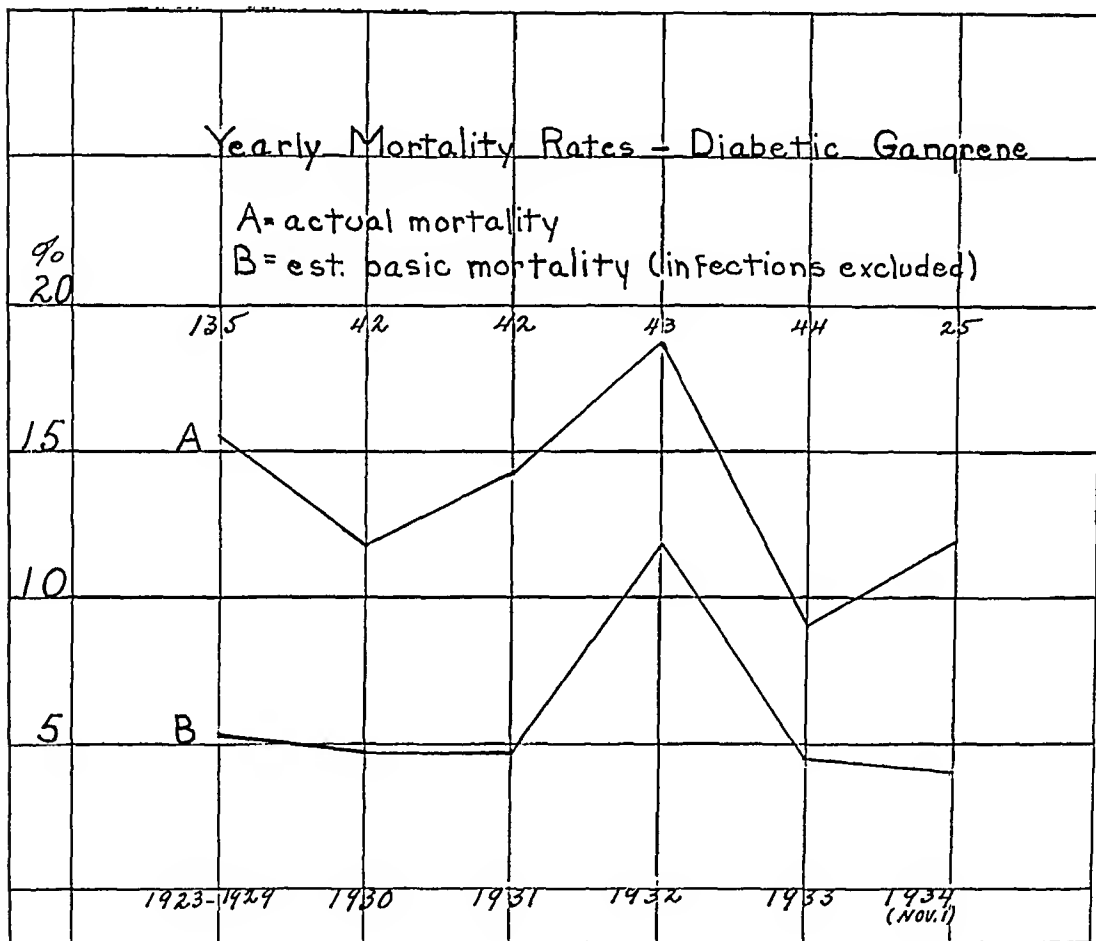
A low or midhigh amputation is the simplest and safest amputation. It should be done on most patients over 70 years of age, when the patient's general condition is poor or when a previous accident such as cerebral hemorrhage or blindness makes the use of an artificial limb impossible.

DIABETIC GANGRENE

Diabetic gangrene appears more frequently at an earlier age (the average of 312 patients was 64 years) than the arteriosclerotic. There is glycosuria

and elevation of blood sugar. A story of intermittent claudication is more commonly obtained than in arteriosclerotic gangrene, and there is more tendency to develop a collateral circulation; in fact, many patients with diabetes develop an adequate collateral circulation without ever having consulted their medical adviser because of symptoms. We have never seen the combination of thrombo-angiitis obliterans and diabetes.

Gangrene of the arteriosclerotic type in a patient with diabetes mellitus is a wholly different problem from that due to thrombo-angiitis obliterans or



GRAPH 1.—Curve A represents the actual mortality following amputations, minor and major, for diabetic gangrene at the New England Deaconess Hospital. Curve B represents the mortality after deaths due to infection have been excluded. The resulting mortality is largely that of the general arteriosclerotic processes.

even uncomplicated arteriosclerosis. The combination of devitalized tissue from lack of arterial supply and the lowered general and local resistance to infection in diabetes mellitus renders much more uncertain not only the future of the part in question, but the life of the patient. There is no warning of the impending septicemia which frequently ensues. The risk of reamputation is great. The reward of an early and accurate determination of when and where to amputate is short hospitalization, early healing without complications, and lower mortality. The penalty of delay or unwise selection of operation is infection in the stump, long convalescence, reamputation, and

a higher mortality. In the group of diabetic patients at the Deaconess Hospital who have come in with failing arterial circulation and lesions demanding hospitalization, 49 per cent of 253 patients during the past three years have required some type of amputation, and of these only 5.6 per cent had a successful amputation of a digit (Tables I and II).

Graph I represents a study of the deaths occurring in these patients at the New England Deaconess Hospital from January, 1923, to November 1, 1934. The general arteriosclerotic processes of the diabetic patient carry with them a definite unavoidable mortality. It is interesting to note from Graph I that it approximates 5 per cent, and that with the exception of 1932 this rate has been almost constant. The difference between this and the actual mortality of about 15 per cent undoubtedly represents the mortality either of delayed or inadvisable treatment; in other words, the mortality where infection has made the difference between success and failure.

The indications for amputation in this group are not difficult to interpret if one has constantly before him: (1) the diabetic patient is frequently as old as his age in years plus the duration of his diabetes; (2) beginning gangrene in a patient with diabetes mellitus usually accompanies serious disease of the coronary and cerebral vessels, is frequently associated with failing eyes and heart, and in most cases is the beginning of a big economic load and a relatively short life expectancy; (3) treatment by trial and error is exceedingly dangerous and usually unsuccessful; (4) prolonged sepsis or pain seriously damages the already poor heart and kidneys of these patients and undermines their morale; (5) once gangrene has started the tendency to develop septicemia is greater than the tendency to develop adequate collateral circulation; (6) if a patient comes in for pain and is unrelieved by two or three weeks of conservative hospital treatment, as previously outlined, gangrene if not actually present will eventually develop and early operation is preferable to continued pain and disability, complete loss of morale and finally amputation or death; and (7) the difference between the usefulness of a supracondylar and Gritti-Stokes stump in the diabetic over 65 is not sufficient to compensate for the increased risk of the latter.

The circulatory requirements for specific operations are not materially different from those already described under senile gangrene, except that one must constantly have in mind the increased risk which the diabetic patient runs from infection and from reamputation.

The guillotine amputation, usually in the upper third of the lower leg, is most useful in patients with diabetes (Table II). It is indicated: (1) in the presence of a bacteremia or septicemia; (2) for gangrene with extensive lymphangitis which does not respond to constant hot boric packs; and (3) for a patient with gangrene and extensive local infection, with severe untreated diabetes. This type of patient may be in such poor general condition that early removal of a large area of infection is indicated and primary suture too uncertain.

SUMMARY

The conservative measures used in the treatment of thrombo-angiitis obliterans, arteriosclerotic and diabetic gangrene in the Peripheral Vascular Clinic at the Massachusetts General Hospital and in the Diabetic Clinic at the New England Deaconess Hospital have been outlined.

The incidence of minor and major amputations in 53 cases of thrombo-angiitis obliterans, 55 cases of arteriosclerotic and 253 cases of diabetic gangrene is given.

The indications for minor and major amputations in the three groups are discussed.

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RELATIONSHIP OF THE PARATHYROID GLAND TO CALCIUM METABOLISM*

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THE parathyroid glands first made their appearance on the anatomic horizon about 50 years ago, Sandström being the first to recognize them as independent organs. For several years they were considered to be aberrant thyroid tissue, but in the late years of the past century the individual function of the parathyroids was finally recognized, and since that time these glands and the rôle played by their secretion in body metabolism have been of vital interest to the clinician, the research worker, and the biologic chemist. Since these glands have been classed among the organs of internal secretion, the amount of literature on the subject has been enormous. One paper on experimental work alone gives 2,600 references and another well over 500. The various theories as well as the case reports have been, to the clinician at least, most confusing. While the last word on this subject is far from being said, certain fundamentals seem to be established and this paper is an attempt on the author's part to clarify for himself the principles of calcium metabolism and the effect of parathyroid secretions on this metabolism and also to work out a practical method of diagnosis and treatment of the cases in which hyperparathyroid function occurs.

In this paper the citation of cases seen at the Orthopaedic and the Graduate Hospitals and direct references to published papers have been deliberately eliminated and the statements presented are only the personal conclusions drawn from these sources. The publication in the near future of the researches of Doctor White and Doctor Stein will give in more detail much of the data on which these conclusions are based.

One sure fact that seems to be beyond dispute is that the parathyroid hormones play their most important clinical rôle in the deposition and extraction of calcium salts in the body skeleton. To understand the pathologic problems a knowledge of the normal mechanism of calcium deposit is necessary. Bones owe their rigidity to the precipitation in them of calcium phosphate and calcium carbonate, the phosphate being by far the more important. The exact formula of this phosphatic deposit is still in question but is of no consequence to the clinician. Although the experimental data on the subject are still incomplete and often very confusing, it now seems to be a well-established fact that our old theories of the specific power of the osteoblastic cells to lay down new bone must be discarded. According to the present theories the precipitation of calcium phosphate in bone is brought about by the local chemical action of an enzyme, called by Kay and Robison phospho-

* The Annual Oration, Philadelphia Academy of Surgery, December 3, 1934.

tase, acting on the calcium and phosphorus ions found in normal body fluids that bathe the bones. All body fluids are identical as far as calcium and phosphorus are concerned and blood serum can be considered as an example. This phosphatase is probably supplied by the cells of peri- and endosteum and it is supposed to act by causing a local overproduction of phosphate. It is also supposed to become active only in the presence of another enzyme known as vitamin D.

The calcium and phosphorus ions of the blood serum are, therefore, the raw materials from which the calcium phosphate of the bone is formed. From a practical standpoint, blood serum may be considered to be a supersaturated solution of calcium and phosphorus ions. Its calcium ions can be divided into three distinct fractions. First, calcium that is normally soluble in any solution of the same composition as serum, the amount being about 2 mg. per 100 cc. of blood. Second, calcium held in solution by the parathyroid hormones present in the serum, 4 mg. per 100 cc., and third, calcium combined with protein, 4 mg. per 100 cc., making a normal total calcium content of 10 mg. The first is known as chemically dissolved calcium, and the second as biologically dissolved calcium, and the third as calcium proteinate. The first two forms are in equilibrium with phosphorus and are active in bone formation. The third form is inert and plays no part in calcification. In other words, chemically and biologically dissolved calcium are the active reservoirs of the materials for bone formation. The chemically dissolved calcium is a constant fraction but the amount of biologically dissolved calcium seems to depend on the amount of parathyroid hormone present at any given time in the blood stream.

It seems to be a primary law of body metabolism that the blood serum must always be in this state of supersaturation and that anything that destroys this condition will draw calcium or phosphorus from some other source to maintain it. To put it in another way—the amount of calcium and phosphorus in the blood stream varies with the amount of parathyroid hormone, and this hormone must be satisfied. Normally, this condition is fulfilled by the salts absorbed from the alimentary tract, but if these be deficient, the calcium and phosphorus stored in the bones can be redissolved to make up the necessary amount.

Vitamin D is another factor in maintaining the calcium-phosphorus balance in the blood. This substance is supposed to aid in the absorption of the salts from the alimentary canal in addition to its action on the phosphatase in the bone. Normally, the ingestion of these salts amounts to about one Gm. of calcium and two Gm. of phosphorus per day and a like amount is excreted, 90 per cent of the excretion taking place through the feces and 10 per cent through the urine.

The evidence now at hand as to calcium metabolism can, therefore, be summarized by these statements. First, the bone building mechanisms depend on the blood serum for their raw materials. Second, in normal blood serum there is an approximately fixed ratio between calcium, phosphorus,

parathyroid hormones and vitamin D, the normal ratio between calcium and phosphorus in the adult being about 10 to 4, and in the child about 10 to 5. Third, that any disturbance of this ratio demands an extra supply of calcium or phosphorus from some source to reestablish this ratio. Fourth, if this extra supply can be obtained from ingested salts no bone changes will appear, but if it cannot be so obtained, the reservoirs of calcium and phosphorus in the bone are called upon to supply the deficiency and decalcification makes its appearance. To state the same fact in another way, if one of the factors of this serum ratio be changed, all must be equally changed to prevent bone disturbance.

In addition to its bone forming functions, calcium together with other ions is supposed to maintain the physicochemical equilibrium necessary for normal irritability of muscles and nerves. Its especial function is to lessen irritability at the neuromuscular junctions both in the heart and in voluntary and involuntary muscle fibers.

In taking up the pathologic changes due to irregularity of parathyroid secretions, the clinical manifestations of lowered parathyroid secretion are now fairly well understood. Lowered parathyroid activity causes a marked diminution in serum calcium, but no loss of the total calcium of the body by excessive secretion, the excess calcium being stored in the spongy bone. The carpopedal spasms, general convulsions, *etc.*, which are the distinguishing signs of tetany, are due, therefore, to the lowering of the total calcium content of the blood by the marked lessening of the biologically dissolved fraction. The introduction of calcium through the alimentary canal, especially when given with a meat free diet, is of distinct use in combating this hypocalcemia and the symptoms caused by it. Of more importance is the use of parathyroid hormone. In 1924 this hormone was first extracted by Collip and has been used both experimentally and clinically. Its intramuscular injection is followed by a rapid rise in serum calcium and an increased excretion of both calcium and phosphorus with diminution of the symptoms of tetany.

The effect of hypersecretion still presents many unsolved problems and the facts presented here are drawn mainly from the experimental and clinical work done at the Orthopaedic Hospital originally by Doctor E. P. Corson White and recently by Doctors White and Stein.

The addition of excessive parathyroid hormone to the blood stream brings about an excess of calcium ions and a lowering of phosphorus. At the same time there is a marked increase in the amount of calcium and phosphorus excreted. Normally, as has been said, 90 per cent of the calcium is excreted by the alimentary canal and 10 per cent by the kidneys. In hyperparathyroid conditions this ratio is reversed and up to 90 per cent of calcium is eliminated by the kidneys and as little as 10 per cent by the alimentary canal. If this excessive calcium excretion persists, marked kidney dysfunction occurs and a marked rise in the phosphorus content of the blood is brought about. Therefore, while a high calcium and a low phosphorus value is seen in the

early stages of hyperparathyroidism, the blood picture may be entirely changed by the loss of kidney function. It is, therefore, necessary to examine the eliminating power of the kidneys in all cases in which the blood picture shows an abnormally high per cent of calcium. This extra calcium in the blood is necessarily drawn from the salts stored in the bone structures and decalcification will occur unless the normal blood balance is restored either by eliminating the causal factor or by increasing the ingestion of calcium and phosphorus from the alimentary canal. The blood picture above described is not necessarily caused by overactivity of the parathyroids—other pathologic states such as sarcoma, metastatic carcinoma, acidosis, and at times tuberculosis, will give the same picture—but the history, the clinical examination, and especially, the roentgenographic studies, will go far in clearing up the diagnosis.

The clinical symptoms of hyperparathyroidism are mainly caused by these changes in the blood, and give the clinical picture of generalized osteitis fibrosa first described by Von Recklinghausen in 1891. The serum calcium rises to 12 mg. or over. Serum phosphorus falls to 2.7 mg. or under. The urinary output is increased to the point of polyuria. Urinary and renal calculi may be found. Renal damage occurs. The muscles weaken and become easily fatigued and often painful. The gastro-intestinal tract often shows signs of irritation, leading to nausea, vomiting, or constipation. The long bones progressively decalcify, becoming thinned and distorted. Eventually fractures may occur. Bone and joint pain and inability to bear weight are early and persistent symptoms. These bone changes are fairly well distributed throughout the skeleton. The bone marrow is damaged and fibrous tissue replaces the normal cells. This fibrous change is progressive and gives rise to tumorlike masses within the bones. Cystic changes due to necroses occur, and when the fibrous tissue be invaded with giant cells, giant cell tumors will form. These giant cells can be found also in the walls of the primary cysts. Hemorrhage into these masses will give the typical brown tumors of Von Recklinghausen's disease.

Given a case in which the diagnosis of hyperparathyroidism is established, is there any quantitative test that will accurately estimate the amount of parathyroid secretion present? From an experimental standpoint such a test can be made which is known as the Hamilton test, and can be used clinically to estimate grossly the amount of parathyroid hormone present. However, we can still rely on the clinical picture plus the repeated blood tests in planning treatment.

This treatment is based on the fact that hyperparathyroid function throws into the blood stream an excessive amount of its secretion, thus destroying its normal ratio with calcium, phosphorus and vitamin D. To overcome this effective treatment must either reduce the amount of secretion or utilize the excess. Three types of treatment must be considered—surgery, roentgen ray, irradiation and diet.

Surgery when used alone is distinctly limited in its effectiveness. The

parathyroid glands vary greatly, both as to their number and their position. They can be classed in two groups—those that are developed from the third bronchial cleft, and those developed from the fourth. The first group, usually two in number, lie behind or in the substance of the thyroid gland. The second group lie along the carotids and trachea and may extend well down into the thoracic cavity. Adenomata of these glands may form and when they can be diagnosed their extirpation is, according to some case reports, of distinct value. Removal of one gland will at times give temporary relief, but the remaining glands tend to hyperplasia and secondary removals are often necessary. Reports in literature of the operative results vary so much that no definite statistics can be given. It would seem, however, that surgical extirpation alone has given permanent results in a very small percentage of cases.

Roentgen ray irradiation is still in the experimental stages. It has been shown that the activity of the glands can be temporarily or permanently diminished by the use of fractional doses given over the whole parathyroid area at three- or four-day intervals. The total dosage employed is usually about 80 per cent of the erythema dose. It has the advantage of covering the whole parathyroid bearing area, but has the disadvantage of inhibiting thyroid function at the same time. A few successful cases of its use in cystic bone disease and giant cell tumor have been reported, but the amount of the dosage and permanence of its effect have not as yet been sufficiently tested.

At the present time treatment by means of absorption from the alimentary canal seems to be the best method of combating the effects of parathyroid hyperfunction. To accurately prescribe the needed amount of calcium and phosphorus intake it is necessary to know the exact degree of negative imbalance in each individual case. That is to say, each case must be tested to determine exactly how much the calcium or phosphorus excretion exceeds the intake. Such testing can be done only with hospitalized patients and by trained technicians. The exact amount of calcium phosphorus intake and output must be measured. In the Orthopaedic Hospital this is done for three consecutive days. The number of grains of calcium and phosphorus that must be incorporated in the daily diet of the patient to overcome the excess of elimination over intake can then be estimated. Calcium chloride, calcium lactate and disodium phosphate and calcium biphosphate are the drugs usually used. To these are usually added an adequate amount of vitamin D, usually in the form of viosterol (250 D).

To sum up the treatment, accurate dietary measures to increase the calcium and phosphorus intake to a point that will restore normal ratio between these salts and the parathyroid hormone in the blood seems to offer the best method of combating hyperparathyroid secretion. Surgery and the use of the roentgen ray in properly selected cases may be of great assistance, but so far as we know now should be used as adjuncts to diet rather than as the only method of treatment.

In cases with normal kidney function the high calcium-phosphorus diet works exceedingly well. However, in those cases in which there has been marked kidney damage, operative removal of parathyroid tissue or irradiation together with a very small amount of extra calcium and phosphorus by mouth will probably save the patient from the pathologic calcification so often caused by damaged kidney.

There are at present so many side issues that are still in the controversial state that to discuss them would only befog the main picture. We can, however, hope that as experimental work goes on, and our knowledge increases, a more clearly cut and practical method of handling the whole field of faulty calcium metabolism may appear and that many of the puzzling problems, such as Paget's disease, nonunion or faulty union of fractures, the various types of rickets, osteomalacia and osteogenesis imperfecta may finally yield to an understanding use of surgery and physiologic chemistry.

THE OBER OPERATION FOR SCIATICA*

HENRY W. CAVE, M.D.

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CASE REPORT.—R. L., a sailor, aged 43. Admitted to Roosevelt Hospital, December 27, 1934, complaining of pain in the right thigh.

History.—Three months before, after sleeping all night in a cramped position, he was seized by a sharp pain in the right leg and thigh. This was continuous from the region of the right hip down the posterior and lateral sciatic region of the thigh and lateral side of the right leg. The pain was aggravated by walking, stooping, coughing and laughing. He was treated on shipboard by the application of hot irons to the painful area, which gave him some, but only temporary relief.

Physical Examination.—Any attempt to flex the thigh upon the body or to extend the lower leg in relation to the thigh caused acute pain. Pressure over the sciatic notch caused great pain. Pressure along the lateral side of the thigh, roughly over the course of the sciatic nerve, was also painful. Doctor Burschell considered the case one of a sciatic neuritis and thought section of ileotibial band should be tried. Roentgen ray of the lumbosacral spine and pelvis was negative. The blood chemistry and Wassermann were also negative.

Operation January 4, 1935, by Doctors Cave and Amendola. Incision six inches long, extending from the anterior superior spine on the right outward and downward, bisecting a line drawn from the upper edge of the greater trochanter of the right femur to a point directly over the spine of the ischium. The tensor fasciæ latæ was found to be exceedingly taut, particularly just below and lateral to the anterior superior spine. An incision seven and one-half inches long was made dividing the fascia lata well out lateralwards. As this was done the fascia seemed to spring apart like a snapped piano wire. It was then undermined for approximately three inches; this seemed to relieve the tension immediately. Several intermuscular taut fibrous bands were cut across. Wound sutured with silk throughout.

Postoperative Course.—Uneventful, except for the amazing disappearance of the pain six hours after the operation. The only discomfort the patient has felt since the operation is the wound pain. Out of bed on the eleventh day without experiencing any weakness of the thigh muscles in the right leg, or pain of which he previously complained.

Microscopic Examination.—Of the few strands of tissue removed at operation, showing a very few scattered lymphocytes, no inflammatory exudate was present.

COMMENT

DR. FRANK R. OBER, of Boston, who first suggested this operation for the cure of sciatica, has had his paper accepted for publication. It is with his knowledge and consent that I am presenting this patient before this society and describing this procedure of his before the actual publication of his paper. In a personal communication, Doctor Ober tells me he has operated upon 24 patients with sciatica by this method, ten of whom were bilateral. He believes that there are several important diagnostic points:

(1) Straight leg raising is usually limited whether sciatica is present or not.

* Presented before the New York Surgical Society, January 23, 1935.

(2) When these patients are asked to sit and bend the body forward, with the legs extended on the examining table, it is very rare for the lumbar spine and pelvis to flex even to right angle. Many of these patients are unable to stoop over and touch the floor with their hands.

(3) In most cases, Ely's sign is present.

(4) The most important diagnostic sign of the contracture is obtained as follows: The patient is placed directly on his side. The examiner places one hand on the pelvis to steady it and grasps the patient's ankle lightly with the other hand, holding the knee flexed at a right angle. The thigh is abducted and extended in the coronal plane of the body. If the contracture described above is present, the leg will remain abducted, the degree of abduction depending on the amount of contracture present. This sign is present both in the conscious and the anesthetised patient. If there is no contracture present, the thigh will abduct beyond the median line.

The treatment of this condition resolves itself into one factor and that is the relief of the contracture. In very severe cases, an operation is performed in the following manner:

(a) An incision is made from just below the crest of the ilium down to the tip of the trochanter directly over the contracted iliotibial band.

(b) The fascia lata is exposed forward as far as the anterior superior spine and backward to the edge of the gluteus maximus muscle. The area of the greatest contracture of the fascia can be seen readily and felt easily.

(c) The fascia is now divided transversely from just below the anterior superior spine to the anterior border of the gluteus maximus muscle. There is immediate separation of the cut edges for a distance of three-fourths to one and one-half inches, depending upon the amount of contracture present. If the operator now attempts to carry out the test described above, it will be shown that the thigh will completely abduct.

DISCUSSION.—DR. RUSSEL H. PATTERSON thought we should be very conservative in our discussion of these cases, first, because there seems to be no consistently definite well identified pathology described. So far, operations have been done empirically for the relief of pain more than for the correction of well understood pathologic disease entities. And, secondly, there are so many different types of operations for sciatica: (a) Several years ago Dr. Percy Roberts, at the Hospital for Ruptured and Crippled, freed the gluteus medius and gluteus maximus muscles from the crest of the ilium and got good results in his cases. (b) For a time there was quite a wave of enthusiasm for injecting saline solution, procaine or alcohol or mixtures of these solutions in and about the sacral canal and sciatic nerve with reports of relief in many cases. (c) There is a group in the Mid-West who have been stripping the gluteal fascia off of the crest of the ilium and getting good results. (d) Recently Freiberg of Cincinnati has called attention to contractures of the piriformis muscle causing symptoms of sciatica.

DR. DONALD GORDON did not believe that what we saw and what doctors called sciatica was a sciatic neuritis. The neurologists demanded that there be hyperesthesia, anesthesia, or motor changes to make a diagnosis of true sciatic neuritis. He did not think nature ever shortened the sciatic nerve so that, as has been done, it could be stretched by manipulative measures to

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relieve in any way a so-called sciatic neuritis. Doctor Ober's procedure, which he carried out on a case of low back pain at Fifth Avenue Hospital last August, makes it seem quite obvious that no sciatic neuritis with true neurologic changes is going to clear up as easily as that. He has felt for many years that sciatica has been associated with contracture of some sort in various places and believes that Doctor Ober's procedure has a very distinct place in treatment of the sciatic syndrome.

DR. CLAY RAY MURRAY had done three of these cases at Presbyterian Hospital and thought that the operation should be limited to selected cases, insisting on all of the signs Doctor Ober has described. Doctor Ober himself stated not long ago that he had no definite idea of the exact nature of the pathology in these cases and agreed that the procedure was somewhat empirical. This is all the more reason for restricting its use to clearly defined cases.

In one of our cases we carried out some rather experimental procedures, for in many it has been presumed that the relief is as much psychic as physical. One of their patients was a carpenter who had suffered for two years from intermittent sciatica, following injury. He had been unable to sleep without sedatives for two months. He presented all the signs Doctor Ober has enumerated. They made a skin wheal along the line of the intended incision. When asked if this relieved the pain, he said it did not. They then made an incision through the skin, first telling him that they were going to cut. Again they asked if this relieved the pain and the patient answered, "No." The Ober signs were still positive. They next anesthetized the fascia along the line of proposed incision. The pain was unrelieved and the Ober signs continued to be positive. Tension was most marked over the gluteus maximus fascia, and not so marked over the fascia of the tensor fasciae femoris. The posterior gluteal fascia was then incised without relief. When, however, they went through the fascia over the outer portion of gluteus, it separated suddenly and widely, and the patient exclaimed, "I felt that all down my leg! Now, my pain is gone!" An immediate test showed the Ober signs now negative. This was the first time the patient had been without pain for two months. Obviously, there was no psychic element in this pain or in its relief.

While it is true that no definite pathology has been described to explain this sciatic pain, in a patient with real sciatica and showing the required signs it is an act of mercy to perform this operation. It can be done under local anesthesia and permits the patient to be out of bed six days or less after the procedure.

DOCTOR CAVE.—It is much more advisable to carry out the procedure under local anesthesia as more information may be obtained in that way. I understand that Doctor Ober has now operated upon 24 cases, ten of which were bilateral. In a personal communication, he has stated that for the most part relief has been almost immediate and satisfactory, though in a few instances the results have come on slowly.

OBSTRUCTIVE JAUNDICE

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CLINICAL obstructive jaundice patients have a visible discoloration of the skin, mucous membranes, and sclera. Chemically, they have a retention and accumulation of bilirubin in the blood stream. The normal content circulating in the blood varies from one part of bilirubin to from 400,000 to 600,000 parts of blood serum. When the concentration reaches from 1 to 40,000 the skin becomes tinged and clinical jaundice appears. Icteric index is the measure of intensity of the color of the blood serum compared with a standard. The normal icteric index varies from three to six. The clinical evidences of jaundice are usually obtained when it reaches 20 or more. Between six and twenty is the latent period. Kupffer's cells in the liver and the reticular cells of the spleen are concerned in the breaking down of the hemoglobin into bilirubin. Jaundice arises from the obstruction of the outlet of the bile capillaries after the changed bilirubin has passed through the polygonal cells of the liver plus the bile salts and consequent obstruction and absorption. Obstructive hepatic jaundice presupposes a normal bile formation and a normal mechanical excretion through the apparently normal liver cells. This mechanism does not continue for any great length of time after obstruction has occurred, for normal bile is no longer secreted nor are the liver cells intact. The jaundice, in the beginning, becomes obstructive due to a mechanical factor. This does not remain long, for as soon as the obstruction raises the hydrostatic pressure of the fluid within the ducts to a degree equal to that of the secretory liver pressure, there must, of necessity, be a cessation of flow or even a reversal of direction of the bile current with a function conducive to intrinsic damage to the liver cells. Bile salts are the specific products of the liver parenchyma. The production of bilirubin, together with bile salts, is a function limited to the liver. No other organ can simultaneously produce these two chemical substances. Along with bilirubin, bile acids are always present in normal blood. With the Szilard method, the bile acids of normal blood vary from five to 12 mg. with an average of seven mg. Katayama, by a modification of this method, failed to find bile acid in normal urine. An abnormally rapid rate of hemolysis elevates the bilirubin of the blood serum but does not influence the concentration of bile acids. On the other hand, the production of liver damage increases the bile acids. But this has relatively little effect upon the bilirubin of the blood serum. Even in those cases of cholecystitis with transient biliary obstruction, there is a very definite increase in bile acids of the blood serum. The concentration of bile acids is also greater in some cases with normal icterus indices than in others with hyperbilirubinemia. Therefore, it is of paramount importance to determine

the bile acids in the blood, in addition to bilirubin, since the increase of bile acids is an absolute indicator of liver injury. Urobilinuria is also an index of the extent of the impairment of liver function. Normally, it does not exceed 30 mg. in 24 hours by the method of Elman and McMaster. But in obstructive jaundice, urobilin is negative and excreted in minute amounts forming a striking contrast to catarrhal jaundice. On the other hand, in obstructive jaundice, there is an increased elevation of the icterus index disclosing a hyperbilirubinemia. The bile acids are increased above normal but they do not parallel the icterus index. There is also a distinctive change in the chemical composition of the blood in obstructive jaundice as shown by an increase of cholesterol which is present in two forms: (a) free alcohol, and (b) combined with acid as esters. Normal blood contains from 160 to 200 mg. per 100 ml. In obstructive jaundice, it is increased and may even reach 1,000 mg. per 100 ml. The icterus index, in these cases, may go as high as 200, bile acids to 75 mg. per 100 ml., and direct and indirect van den Bergh four plus. In making an estimate of the extent of the impairment of liver function, the nonprotein nitrogen, urea, uric acid, and the amino acid nitrogen, therefore, for an adequate estimation of complete liver function, and differentiation of the types of jaundice, biochemical analyses must include icterus index, bile acids, blood sedimentation test, cholesterol, nonprotein nitrogen, urea and amino nitrogen, uric acid of the blood, and urobilin excretion in the urine.

Blood sugar determinations are essential as the carbohydrate metabolism is also disturbed by virtue of the fact that the liver regulates, quantitatively, the amount of carbohydrate that is furnished to the body cells in the varying conditions of carbohydrate intake and bodily activity. The internist should order insulin in the suitable cases.

Since over 50 per cent of the fatal cases are due to postoperative hemorrhage, the clotting time is a very essential test, as the calcium of the blood unites with the bile salts and pigments in an attempt to detoxify the toxic state. In many of these cases, there is a hypochlorhydria as is evidenced by the blood determination of the chlorides. Inflammatory infiltration about the ducts and even about the finer bile channels within the hepatic lobule, along with exfoliated epithelium and thrombic formation within the ducts, themselves, are further evidences of the severe injury to the liver.

During the past ten years, two noted changes have taken place, as is evidenced by the referring of jaundice patients to the surgeons by the internists, especially in those cases where the bile salts plus bilirubin are found together in increased or abnormal quantities, showing obstruction. Also, if I may digress, the direct opposite of sending ulcer cases, especially duodenal and marginal, to the internist with the conviction that patient, persistent dieting and medical care will solve many of these cases where operative procedures are constantly failing and are, therefore, discouraging. The different tests enumerated above, along with the routine physical examination including Wassermann, blood count, especially Schilling, cardiogram, and roentgenogram impresses one with the seriousness of these cases and also the importance

of group consultations, particularly as to the advisability of any operative procedure. A surgeon should have a thoroughly adequate experience before he undertakes to operate on these cases. In the long standing toxic jaundice cases, he is entitled to a helpful sympathy since the mortality rate is high.

All operative procedures, without exception, should be done in two stages. The first one is for drainage of the gallbladder when the obstruction is below the entrance of the cystic duct. It is accomplished by using a modification of the Kocher or Courvoisier incisions, making it more longitudinal. After exploring the common duct and determining the point of obstruction, which is below the cystic duct entrance in 90 per cent of the cases, the gallbladder fundus is then brought up to the aperture of the abdominal incision. Following sufficient packing and walling off, this viscus is drained with a trocar and cannula connected with a rubber tube and the edges of the aperture are held taut with Allis clamps. The female portion of a small size Murphy button is then introduced into the opening of the gallbladder. The male end of the button is inserted into one end of a long rubber drainage tube, following which the corresponding parts of the Murphy button are snapped together. Drainage is instituted in this way and suction is applied if necessary. The advantages of the Murphy button are: the absolute hemostasis of the edges around the opening of the gallbladder, its quick disconnection, and a further important function in the secondary stage of operation. Some surgeons prefer a 28 or 30 F. Pezzer catheter. Following the drainage, performed under a local anesthesia, the chemical analyses of the material obtained and a further check-up in the blood and urine chemistry is regularly made. The improvement that some of these cases show after 72 hours of drainage is remarkable.

The consultants, having agreed upon the time for the second stage of operation, then make a Mayo-Robson or Mayo incision after a spinal anesthesia has been given. This incision is closer to the median line than the first one. If the operator finds that he is dealing with a malignancy of the pancreas, he should disconnect the gallbladder fundus, with its contained Murphy button, and use the other end of the button that was inserted in the drainage tube, and after proper sterilization, incise the neighboring first portion of the duodenum, suture in this part of the Murphy button, and connect the two. Drains are then inserted down to Morrison's pouch and to the Murphy button anastomosis.

If the obstruction consists of a large impacted stone in the lower portion of the common duct, as is so often the case, this area should be dealt with by reflecting and retracting the second portion of the duodenum after incising the peritoneum on the right side. This approach is very simple and easy compared with McBurney's transduodenal approach. A T-shaped tube is then inserted. The gallbladder is not disturbed, since we have an actual or potential pancreatitis to combat, and our gallbladder drainage is absolutely essential in this complication.

If, after exploring the cause of the obstruction, we find a complete stenosis

of the lower part of the common duct with repair out of the question, we then use the proximal stump and insert the end into the proximal duodenum. If the end inserted is split into four parts, using longitudinal incisions of half a centimeter, each of these parts can be sutured to the duodenal wall after their insertion by first threading a nontraumatic suture through the edge before insertion. Greater security is given, along with the bile current, by keeping the edges open so that no stenosis can occur.

Even in those cases of common duct stenosis with virtual destruction, a direct anastomosis should be used. This should be possible by hooking a dull retractor, shaped like an aneurysm needle, over the V-shaped juncture of the hepatic ducts to steady our anastomosis. This is especially true on the cadaver in thin subjects where it is comparatively easy to repair the tissues even though a small portion of the common duct is left with which to make an anastomosis between the duodenum and the common duct.

The point that I wish to emphasize is never, under any circumstances, resort to the old and obsolete technic which is exemplified by the Sullivan tube method, in which a space is left filled in by a rubber tube and covered over by various methods. From my observations, they are never successful since the stenosis becomes more acute and the adhesions aggravate the extreme seriousness of further exploratory dissection. Therefore, a direct anastomosis of at least a part of the cut edges of the common duct is essential. Failing to accomplish this, an anastomosis of even a small stump of the upper portion of the common duct to the duodenum should be made. On the cadaver in thin subjects, it offers no great difficulty.

CONCLUSIONS

To improve the clotting time, transfusions of whole blood and glucose solutions should be administered. At the present time, we fully appreciate the extreme value of these solutions in this complication, a fact that was unknown a few years ago. Ten per cent calcium chloride solutions and ampules of calcium agglutinate are also useful, in this condition, since they increase the blood calcium. Chloride deficiency is improved by the introduction of normal saline solutions and diluted hydrochloric acid solutions by mouth. One dram should be given daily in divided doses, gradually increasing the amount. Insulin should be administered in those cases showing increased blood sugar. The diet consists of various fruit juices and cereals, unless contradicted by some special complication.

These patients suffer a fall of body temperature during the operative procedures. This condition has to be counteracted by using hot laparotomy pads, short exposures, and a warm operating room.

The loss of fluids, caused by the drainage, must be counter balanced by the introduction of glucose and saline fluid. After the first 72 hours, the drainage tube can be clamped for a certain time each hour in those cases where it is possible to do so.

The time factor is one of the most serious considerations because, at best,

the patients are poor surgical risks. It is essential to make a thorough check-up to make sure that the drainage tubes, Murphy buttons, and syringes are in perfect condition before operating. This may sound strange to the uninitiated, but the Murphy buttons fit only in pairs and drainage tubes have been known to have a lumen that was imperfect.

There appears to be little or no excuse for the delay in sending these cases to a hospital where a proper work-up and diagnosis can be made. Yet, daily, we see cases admitted in the late stage of jaundice due to obstruction.

SUBCUTANEOUS PERFORATION OF THE JEJUNUM*

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THE number of deaths resulting from trauma to intra-abdominal organs has increased in the past decade. In some of these cases, death has occurred almost immediately, because of extensive injuries to the body, the intra-abdominal lesion forming only a part of the general picture and not, as a rule, the chief cause of death. In a great many instances, however, the patients have lived for many hours after the accident, subsequently dying directly as a result of trauma to the abdominal viscera. It is in these cases that earlier diagnosis and treatment might lessen the high mortality of these injuries. Abdominal injuries naturally separate themselves into two groups: (1) Percutaneous injuries, caused by foreign objects such as bullets, knives, and so forth, in which a penetrating lesion of the abdominal wall is present, and in which the diagnosis of injury to the underlying viscera is made relatively easy, and (2) subcutaneous injuries, caused by a blunt force applied directly to the abdominal wall or even indirectly to the body, as in falling, lifting, or straining. In these injuries, no evidence of trauma to the abdominal wall is present, and the diagnosis and method of treatment in these cases are often exceedingly difficult.

Geill¹¹ stated that subcutaneous injuries involved the abdominal viscera in the following order: liver, spleen, kidneys, intestines, stomach, bladder, and pancreas; the intestines were involved in 11.1 per cent of his cases.

Intestinal rupture is caused in three ways: (1) By crushing, in which the intestine is caught between some fixed structure such as the spine or pelvis and the direct force is applied perpendicularly to the abdomen; (2) by tearing, in which the force is applied tangentially to the abdominal wall, causing the bowel to be torn from its attachments, and often tearing the mesentery also, and (3) by bursting from increased intra-intestinal pressure exerted by fluid or gas caught in the bowel between angulations of the wall. In TABLE I are listed cases of rupture of the intestines reported by various authors and tabulated according to the situation of the perforation. In some cases, the site of rupture was noted as merely "small intestine" with no specific localization to the duodenum, jejunum or ileum; in other cases, no note was present concerning the situation of the lesion, while in still others, no perforation was found at operation. Allowing for these discrep-

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ancies, it is seen from TABLE I that the small intestine was the site of rupture in more than 90 per cent of the cases, the jejunum and ileum were involved about equally, and together accounted for about 80 per cent, while the duodenum and large intestine were involved in about 10 per cent of the cases. In reviewing the cases reported in the literature, it was noted that the beginning of the jejunum, just distal to the ligament of Treitz and the end of the ileum, in the region of the ileocecal attachment, were by far the most frequent sites of traumatic perforation. This is undoubtedly attributable to the limited mobility of these sections, and their proximity to fixed bony structures, so that conditions conducive to perforation are present when extreme force is applied to the abdomen.

TABLE I
Situation of Subcutaneous Ruptures of the Intestines

Author	Duo- denum	Jejunum	Ileum	Cases Small intes- tine*	Large intes- tine*	Not noted	Total
Poland ¹⁹	4	14	16	22	5	0	61
Curtis ⁷	6	44	38	21	4	3	116
Makins ¹⁵	1	6	7	2	5	0	21
Gage ¹⁰	10	20	43	0	6	6	85
Lund ¹⁴	0	5	6	5	1	2	19
Berry and Guiseppi ³	26	32	32	25	10	7	132
Tschistossersdorff ²⁵	1	23	25	0	3	0	52
Battle ¹	32	111	59	2	11	7	221
Stanley ²⁴	0	3	1	0	0	0	4
Quain ²⁰	0	4	3	0	5	0	12
Massie ¹⁷	4	14	8	3	1	4	34
Vance, ²⁶ 1923†.....	3	4	5	0	2	0	12
Rowlands ²²	23	157	158	0	43	0	381
Richter† ²¹	0	1	3	4	3	0	9
Vance, ²⁷ 1928.....	0	3	4	3	0	0	10
Beekman ²	0	0	2	0	0	0	2
Cooke ⁴	3	6	2	0	1	0	12
Totals.....	113	447	412	87	100	29	1,183

* Situation not given more definitely.

† Multiple ruptures.

Perforation of the intestines of children is not a very common occurrence; the liver is the organ most often injured in abdominal trauma in childhood. Beekman found only two cases among a series of 59 children admitted to the Bellevue Hospital with abdominal injuries. In TABLE II are listed some cases of rupture of the intestine collected from the literature, in which the age of the patient was given as 12 years or less. They are relatively few in contrast to cases of this injury occurring later in life.

TABLE II

*Data Concerning Subcutaneous Rupture of Intestines of Patients Twelve Years of Age or Less.
The Quantities Given Here Are Included in Those Given in Table IV*

Author	Cases	Patients operated on	Died	Operative mortality, per cent	Died without operation	Total mortality, per cent
Poland.....	3	0	0	00.0	3	100.0
Curtis.....	2	0	0	00.0	2	100.0
Makins.....	4	4	4	100.0		100.0
Lund.....	2	2	1	50.0		50.0
Berry and Guiseppi.	24	13	9	61.5	11	83.3
Quain.....	4	4	1	25.0		25.0
Vance, 1923.....	2	2	2	100.0		100.0
Massie.....	8	5	3	60.0	3	75.0
Richter.....	11	9	3	33.3	2	45.4
Moynihan ¹⁸	9	7	4	57.1	2	66.6
Vance, 1928.....	2	2	2	100.0		100.0
Beekman.....	2	2	1	50.0		50.0
White.....	1	1	0	00.0		00.0
Cooke.....	3	0	0	00.0	3	100.0
Totals.....	77	51	30	58.8	26	72.7

CASE REPORT

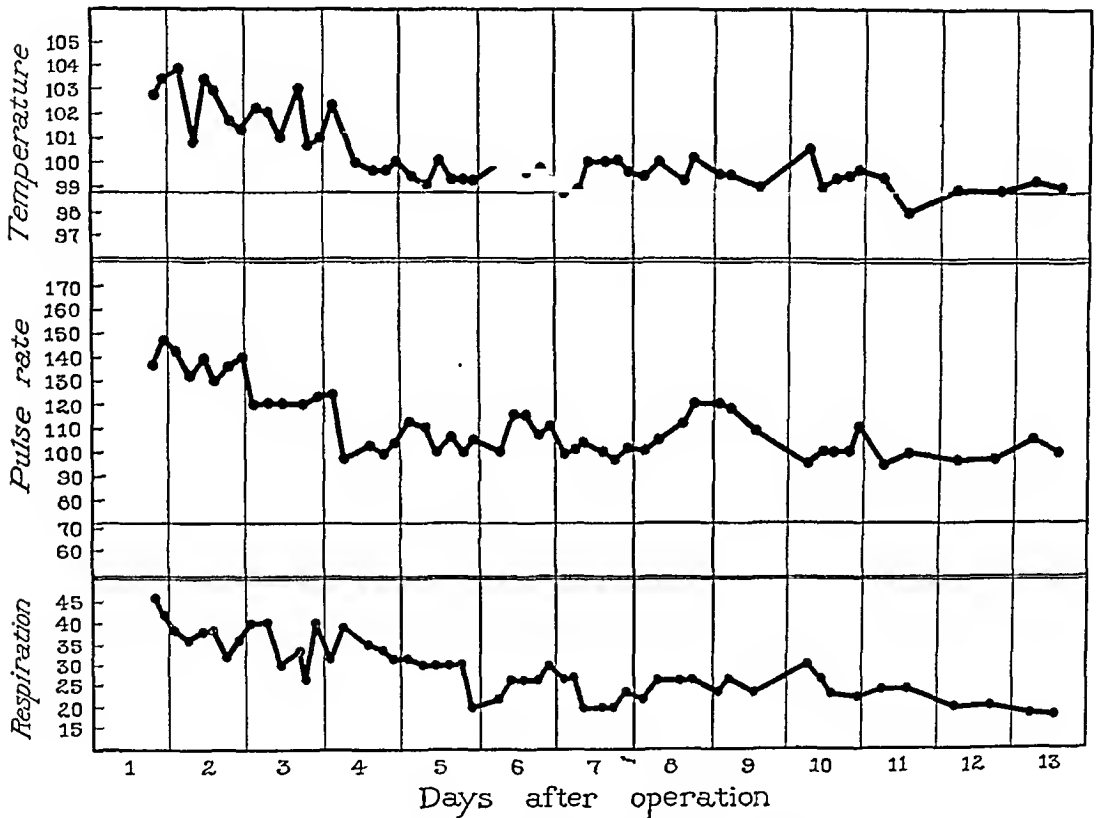
A white girl, 4 years 11 months of age, was admitted to the hospital November 28, 1934, complaining of abdominal pain. About two and one-half hours before admission, while playing, she had pulled a flower box, which measured about four feet by ten inches by ten inches (120 by 25 by 25 cm.), down upon herself. The box fell a distance of about three feet (90 cm.) with considerable force, pinning her beneath it. She was unable to extricate herself, but the box was removed after a few minutes. The child did not lose consciousness, and was able to arise and walk. Shortly thereafter she became nauseated and vomited. There was no hematemesis. She complained of some pain across the upper part of the abdomen, but this was not severe. An hour before she was brought to the hospital, the abdominal pain had become more severe, she had vomited again, had become cold and pale, and felt faint.

She presented a typical picture of shock; cold, moist extremities, marked pallor, respirations 46, thoracic in type. Pulse 136, weak and thready (Graph 1). The blood pressure could not be obtained (Graph 2). Immediate intravenous injection of 6 per cent solution of acacia was started, the foot of the bed elevated and heat applied to the extremities.

On physical examination no contusions, abrasions, or lacerations were found on the abdominal wall. There was tenderness, graded 3, throughout the abdomen, and rigidity, graded 3, of the abdominal muscles. The patient could not localize the abdominal pain to any particular area. Hepatic dulness was not obliterated nor was there any shifting dulness in the flanks. There was no abdominal distention, and the liver and spleen could not be palpated because of the tenderness and rigidity. The lungs were negative to percussion and auscultation. An occasional extrasystole could be heard over the apex of the heart. The reflexes were not abnormal and there was no paralysis. Erythrocytes 3,770,000, leukocytes 17,600, polymorphonuclears 55 per cent. According to the parents the patient had voided grossly normal urine before she came to the hospital. Urinalysis in the hospital disclosed albumin graded 1, a slight trace of sugar, and about six pus cells to the high power field. There were no erythrocytes in the urine. The child's condition

gradually improved, and after 350 cc. of solution of acacia had been given, her blood pressure was 110/60. Skin was warm. Pulse 136 but of better quality. It was apparent that she was suffering from a traumatic intra-abdominal lesion which required surgical treatment; therefore she was brought immediately to the operating room.

Under gas-oxygen-ether anesthesia a small right rectus incision was made, approximately five and one-half hours after the accident. As soon as the peritoneal cavity was opened, free fluid but no blood was encountered. Starting at the terminal part of the ileum, the entire small intestine was carefully examined, until about two inches (five cm.) distal to the ligament of Treitz, a perforation about one cm. in diameter was found. This was closed, and the area inverted with two continuous rows of chromic catgut. There was no evidence of injury to stomach, duodenum, large intestine, mesentery, liver, or spleen. It was felt safer to leave a small Penrose drain in the lower angle of the wound. The complete procedure took 35 minutes.



GRAPH 1.—Record of temperature, pulse and respiration.

Fluids were given intravenously, and in increasing amounts by mouth, until, on the sixth day, the child was taking a liquid diet. The temperature and pulse rate gradually returned to normal. The drain was removed on the tenth day. Skin sutures on the twelfth and the silkworm tension sutures on the thirteenth days, when the patient was dismissed from the hospital.

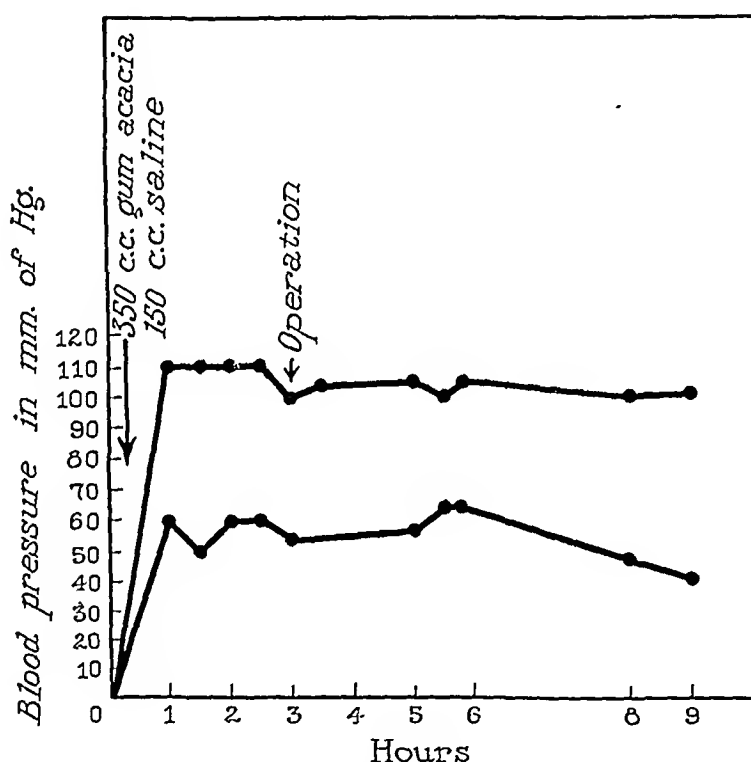
No one sign is pathognomonic of intestinal rupture, but the diagnosis has to be made from the general clinical picture, including the history and a carefully performed physical examination. In most cases, pain is the outstanding symptom. It is present usually from the beginning, is constant in duration, dull, aching and not colicky in nature. It is diffuse throughout the abdomen early, and may then become localized. White²⁸ reported a case of ruptured jejunum, in which the pain was localized to an area below and

JEJUNAL PERFORATION

to the left of the umbilicus; the localization was similar to that of the pain of gastrojejunal ulcer.

A variable degree of shock is present. This may follow immediately after the injury, or may be delayed. Many reports of cases are found in the literature in which the patient felt well after the injury, except for the abdominal pain, and walked into the hospital apparently in good condition, only to develop the signs of shock later. With shock are present the cold, clammy extremities; rapid, thready pulse, and lowered blood pressure. Nausea and vomiting are present, and continued vomiting, especially after recovery from the initial shock, is a valuable early sign of intestinal perforation.

Tenderness is present but usually is of no aid in early recognition of



GRAPH 2.—Record of blood pressure.

the situation of the perforation, because it is usually diffuse. Rigidity of the abdominal muscles is probably the most valuable single sign of intestinal injury. It is present early in almost all the cases, is persistent, and even under the influence of morphine abates very little. Distention of the abdomen does not occur early, but is a manifestation of the peritonitis that later develops, and is a sign of poor prognosis when seen early.

Shifting dulness in the flanks early in the course is diagnostic of intra-abdominal hemorrhage, either from the mesenteric vessels or from the solid viscera. It is doubtful if, in early cases, enough intestinal content is present in the peritoneal cavity to produce this sign. Obliteration of the area of hepatic dulness, often mentioned by some as diagnostic of intestinal perforation, is seldom present in the early stages and is therefore useless as an early sign. One should look for it at the first examination, however, because its

detection at a later examination then becomes of diagnostic importance. Emphysema of the posterior abdominal wall is indicative of retroperitoneal rupture of either the duodenum or colon.

The pulse, temperature, blood pressure, and respirations are dependent on the presence or absence of shock. When the diagnosis is not obvious, a check on these vital signs every 15 minutes will often aid in establishing an early diagnosis, so that early surgical treatment can be carried out. The temperature, which at first is usually subnormal, rises after the patient recovers from the shock, and the pulse becomes slower and of better quality. A constantly rising pulse rate is of diagnostic importance, and if combined with an increased respiratory rate, surgical exploration is indicated.

Examination of the blood usually reveals moderate leukocytosis. When bleeding is present, either from the mesenteric vessels or from a solid viscus, the leukocytosis is more marked and there is a fall in the number of erythrocytes and in the hemoglobin content. Hourly examinations of blood should be made.

In regard to the diagnosis of intestinal perforation, then, it may be said that consideration of all the signs and symptoms is the important factor. No one sign or symptom is absolute, and no sign or symptom is to be disregarded. If a definite diagnosis cannot be made when the patient is first seen, careful observation, with repeated physical and blood examinations, as well as frequent determinations of the vital signs, should be carried out. It should be remembered that intestinal rupture may result from an apparently trivial injury, and also symptoms of rupture may be delayed. Cope,⁵ in writing of the early diagnosis of this condition, stated that he would submit a patient to laparotomy if, in the absence of thoracic and renal injury, the following signs and symptoms were present: (1) severe abdominal pain persisting for six hours, accompanied by vomiting, gradually rising pulse rate, local rigidity, and deep local tenderness; or (2) absent or slight abdominal pain, with a steadily rising pulse rate, especially if the patient is restless and listless.

The importance of making an early diagnosis, and operating early, is seen from the figures presented by Siegel,²³ who studied the records of 376 cases in which operation was performed, and showed the increasing mortality as the time between the injury and the operation increases (TABLE III).

TABLE III
*Mortality in Relation to Interval between Injury
and Operation (Siegel)*

Time of operation in relation to time of the injury	Mortality, per cent
Within the first 4 hours.....	15.2
From 5 to 8 hours.....	44.4
From 9 to 12 hours.....	63.6
After 12 hours.....	70.0

From TABLE IV it is seen that the total mortality in both cases operated and nonoperated is about 73 per cent, approximately the same as that for children less than 12 years of age, as is seen in TABLE II. The operative mortality derived from the totals is about 60.7 per cent (TABLE IV) and it is

TABLE IV

Data Concerning Subcutaneous Rupture of the Intestines of Patients of All Ages. The Quantities Include Those Given in Table II

Author	Cases	Patients operated on	Died	Operative mortality, per cent	Died without operation	Total mortality, per cent
Poland.....	61	0	0	00.0	61	100.0
Curtis.....	116	12	12	100.0	104	100.0
Siegel.....	376	376	194	51.6		51.0
Makins.....	21	15	12	80.0	6	85.7
Kirstein.....	18	18	10	55.5		55.5
Gage.....	85	40	23	57.5	45	80.0
Eisendrath ⁸	40	40	21	52.5		52.5
Lund.....	19	15	8	53.3	4	63.1
Berry and Guiseppi.....	132	84	67	79.7	48	87.2
Tschistosserdorff.....	52	47	39	82.9	5	84.6
Lockwood.....	27	13	8	61.5	14	81.5
Battle.....	221	124	76	56.1	97	78.3
Stanley.....	4	4	1	25.0		25.0
Quain.....	12	12	5	41.7		41.7
Massie.....	34	24	17	70.8	10	70.6
Vance, 1923.....	12	5	5	100.0	7	100.0
Moynihan.....	61	47	35	74.4	14	80.3
Vance, 1928.....	10	10	5	50.0		50.0
Cooke.....	12	1	1	100.0	11	100.0
Totals.....	1,313	887	539	60.7	426	73.4

about the same, 58.8 per cent, for children (TABLE II). The high mortality is accounted for chiefly by the late operations, when peritonitis is developing or has developed. However, another reason for the high operative mortality is that patients are in a state of severe shock. Preparation of patients who are in shock is an important part of the treatment, and one of us (Counselor⁶) previously has pointed out the efficacy of 6 per cent solution of acacia in treating shock immediately, whether or not hemorrhage has taken place. Martin¹⁰ has pointed out that following penetrating wounds of the abdomen, the important complications, in order, are shock, peritonitis, and hemorrhage. This is also true following subcutaneous injuries of the abdomen. Fraser and Drummond⁹ have expressed the belief that very little intestinal leakage occurs from the perforation during the first six hours because peristalsis is absent and because the everted mucous membrane acts as a plug. Even in complete tears, according to the belief they expressed, the leakage is not great during the early hours, because of the contraction of the circular muscle layer in the severed ends. This substantiates the belief that immedi-

ate operation on a patient who is in shock only adds insult to injury, and that it is better to improve the patient's condition first by means of measures to combat shock. The immediate treatment then becomes the treatment of shock when it is present, but if shock is absent, one should not wait for it to appear but immediately perform laparotomy.

The outlook is better for patients whose perforations are high in the intestinal tract than it is if the perforations are lower, because of the relatively cleaner intestinal content of the higher segments, and hence the less likelihood of peritonitis developing. However, high tears are less likely to cause such early and striking symptoms as those in the lower part of the tract, so patients whose tears are high usually come to operation later. Among children who have sustained visceral injury, the younger the child, the more serious the outlook.

In carrying out the surgical treatment, that procedure which can be done most quickly, with the least amount of shock to the patient and trauma to the tissues, should be chosen. The operation should not be prolonged, and a constant check should be kept on the blood pressure, pulse, and respiration of the patient, so that immediate treatment can be undertaken if shock supervenes. Long time-consuming resections should be avoided unless the viability of the injured intestine is questionable.

The abdomen may be opened by an incision through either rectus muscle, to give the best exposure, unless localizing signs are present which indicate the section of the bowel involved. In these cases, the incisions may be placed to facilitate repair.

After the peritoneum has been opened, if active bleeding is present, it is better to bring the intestines outside the abdomen and immediately to control the bleeding. If there is no hemorrhage, it is better to examine the bowel and mesentery minutely, starting at some fixed point such as the ileocecal region, and drawing several inches of bowel out at one time, following up or down the whole intestinal tract. When a perforation of the bowel is found it is better to cover it with a warm, moist sponge and lay it aside until the whole intestine has been examined. Sometimes, resection of a portion of bowel may be necessary because of multiple lesions close together, or because of a damaged blood supply in the mesentery, and if a perforation has been closed and then it is found that resection of the loop containing the closed perforation is necessary, much valuable time has been lost.

The question of drainage is an individual one, and depends on the conditions found at operation. The same principles apply in these cases as in all operations on the abdomen.

The postoperative care is concerned with seeing that the patient is kept comfortable by the use of sedatives, and that the intake of fluid is adequate; fluid may be introduced by the intravenous, subcutaneous or rectal routes. After operation, feeding by mouth may be started with sips of water and the amount and consistency of the ingesta may be increased as the patient

tolerates the increase; gradual progress is made through liquid and soft to a normal diet.

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THE INDICATIONS FOR GASTROSTOMY AND JEJUNOSTOMY

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It is generally agreed that the Janeway, or any good gastrostomy, works admirably in the presence of obstructive growths of the pharynx and of many of those of the esophagus, after stricture of the esophagus, and following pressure upon the gullet from mediastinal tumor. There are, however, certain destructive growths of the esophagus, particularly those of the distal portion, and of the cardia after which a gastrostomy continues to leak (Fig. 1).

It is recognized that a gastrostomy in a carcinomatous stomach facilitates the radiologist in implanting radium in the gastric tumor. This, too, may be accomplished through a gastrotomy following which a jejunostomy may be performed and the stomach allowed to remain at rest. If, however, some special indications call for repeated approach to a gastric growth through a gastrostomy, one must occasionally choose between its advantages and the disadvantages of gastric incontinence.

The combination of gastrostomy and pathology in the cardiac end of the stomach involving the lesser curvature has repeatedly demonstrated incontinence of the gastrostomy. There appear to be two essential factors in this lack of control of the fistula; namely, the impairment of the gastric vagomotor nerves and the resultant digestive effects upon the abdominal wall about the fistula. The loss of fluids and skin irritation so aggravate the distress of the patient that the surgeon may feel compelled to attempt closure of the gastrostomy.

Encroachment upon the gastric vagus, particularly fibers entering into the pyloric branch, may either stimulate these fibers so as to produce a vagotonic stomach or destroy these fibers so as to divorce the pyloric portion from the fundic part of the stomach, thus producing a diffuse pylorospastic stomach. The former condition is depicted in the psychopathic patient with vagotonia^{1, 2, 3} (Fig. 2), with eructations and vomiting as prominent symptoms. The latter condition is represented by the stomach after annular resection.⁴ In both of these nervously impaired stomachs it is believed that the intra-gastric pressure is markedly increased. The fistula presents a means of least resistance and a site for regurgitant fluids. Occasionally, after gastrostomy feeding, such a patient experiences epigastric pain synchronous with painful gastric contractions (at 15 to 20 second intervals) and immediately following these spasms one may observe jets of gastric contents from the mouth of the fistula. These patients cannot vomit any more than they can swallow but they do pass through the early painful stage of the act of vomiting.

Radiographs of these individuals indicate spasms of the pylorus or stomach characteristic of vagotonia. Some of the chyme passes on into the duo-

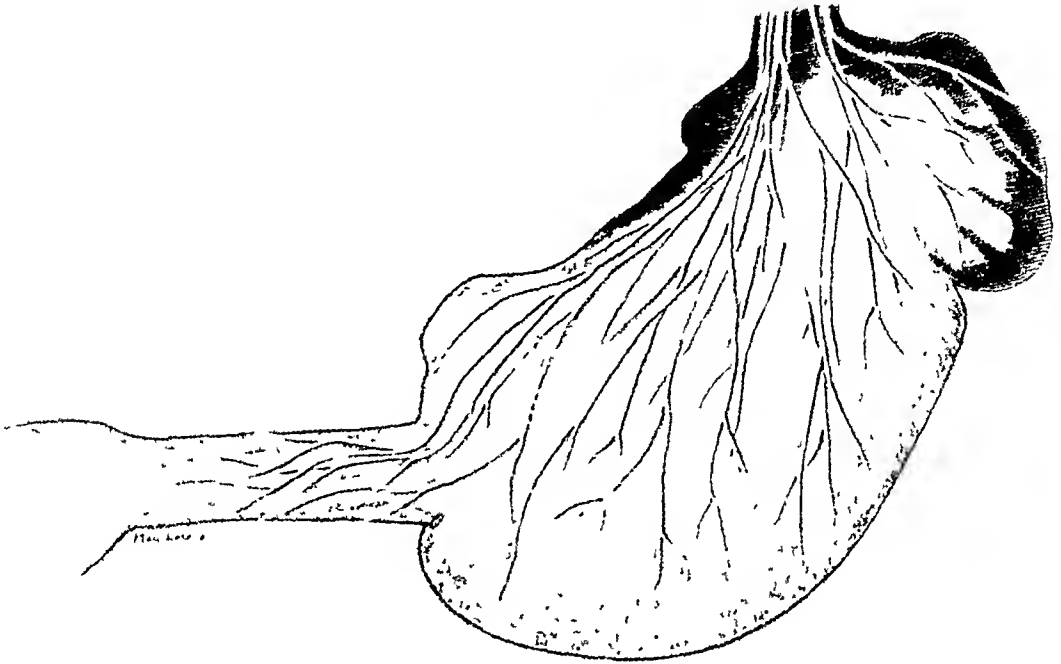


FIG. 1.—Drawing of recent case representing malignant growth at cardia and lesser curvature. The left vagus is sketched in to indicate relation of nerve fibers to tumor. Gastrostomy in this patient was followed by gastric colic and incontinence at stoma.

denum and when once beyond the pyloric sphincter continues on through the intestine. Large doses of belladonna, in certain cases at least, are of no avail in lessening the gastric colic. Possibly the impairment or destruction of the

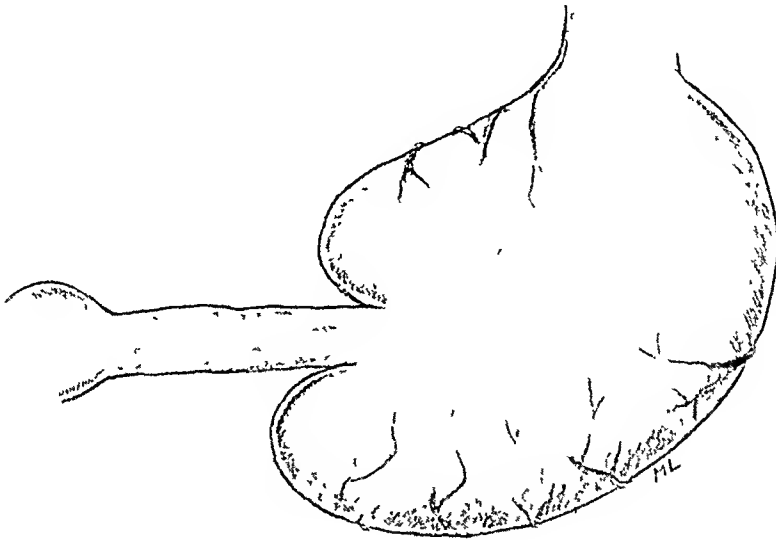


FIG. 2.—Drawing of vagotonic stomach in psychopathic patient with marked regurgitation and vomiting. Diffuse pylorospasm was observed on radiogram and in open abdomen.

vagus nerve at the cardia renders ineffective the action of atropine upon the termination of this nerve within the stomach wall. These unfavorable

stomachs occur infrequently and are thought to be vagotonic from mediastinal or gastric irritation.

Wolfer⁵ has published a similar conclusion regarding the wisdom of performing jejunostomy rather than gastrostomy for these lower esophageal cancers, chiefly because of the severe colicky pyloric pain experienced in such cases.

This condition of gastric malfunction is not to be mistaken for the too frequent instances in which acute dilation follows operation. In this latter condition the operative procedure may have been carried out smoothly and expeditiously and the patient returned to bed in a very satisfactory state. Proper feedings in proper amounts may have been regularly administered; but if one catheterizes the gastrostomy he may obtain as much as two quarts of foul material. It is remarkable because the stomach of such an individual at laparotomy is often small, atrophic, and apparently incapable of such dilation. This can be prevented or relieved by instructing the nurse in charge to aspirate or to gently irrigate the stomach before the introduction of each feeding.

The principle of rest for a diseased stomach would seem to contra-indicate using such a stomach as a feeding reservoir. It is the practice on the Third Division, Bellevue Hospital, after determining inoperable malignant involvement of the stomach, either to close the abdomen at once or to perform jejunostomy.

In those instances of destructive esophageal growths in which it is feared that motor gastric disturbances will interfere with satisfactory emptying at the pylorus after gastrostomy, one may add section of the branches of the principle anterior nerve on the stomach wall.⁶ This has been carried out in several such cases with apparent encouraging results.

If one desires to explore manually it is thought wise to make a median or right paramedian laparotomy and use the left rectus by means of a stab wound as the site for the jejunostomy. The exploratory wound may then be closed independently and protected by the dressings from exposure to digestive juices. This is important because if jejunal secretions seep into the depths of the wound necrosis and protein absorption follow with high temperatures, rapid pulse, pallor, *etc.*, suggestive of the "shock" syndrome following protein intoxication. Preserving the rectus fibers provides some sphincteric control and guards against wound contamination. In most instances observations before operation suffice to disclose the degree of metastasis so that the incision for jejunostomy is all that is necessary.

From an examination of the case records of the Third Division at Bellevue Hospital the past five years (1930-1934), there appear 43 cases of gastrostomy. Of these ten succumbed so soon following operation as to make a determination of the functioning of the gastrostomy impossible. Of these, five died of shock, four of peritonitis and one of pneumonia.

It is interesting to note that these cases have been increasing in number, there being none in 1930, seven in 1931, 22 in 1932-1933 and 14 in 1934.

Of the 33 cases studied, five were considered not working well from the standpoint of gastrostomy, and 28 as functioning satisfactorily. An examination of the five unsatisfactory cases indicates that the lesion was at the cardia in three (60 per cent) and in the esophagus above the cardia in two (40 per cent). In the 28 successful gastrostomies, in five (18 per cent) the pathology was at the cardia, four (14 per cent) in the lower third of the esophagus, seven (25 per cent) in the middle third, four (14 per cent) in the upper third, and eight (28 per cent) in the pharynx (Figs. 3 and 4).

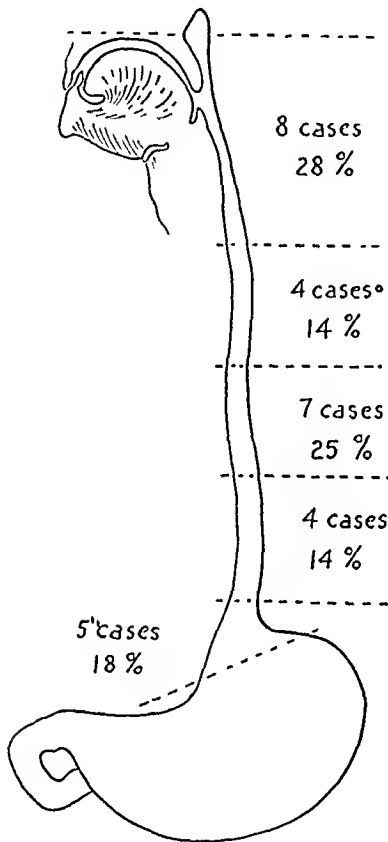


FIG. 3.—Diagram based on Table I representing location of esophageal disease for which gastrostomy was performed and worked well. Note 18 per cent located at cardia and 82 per cent above.

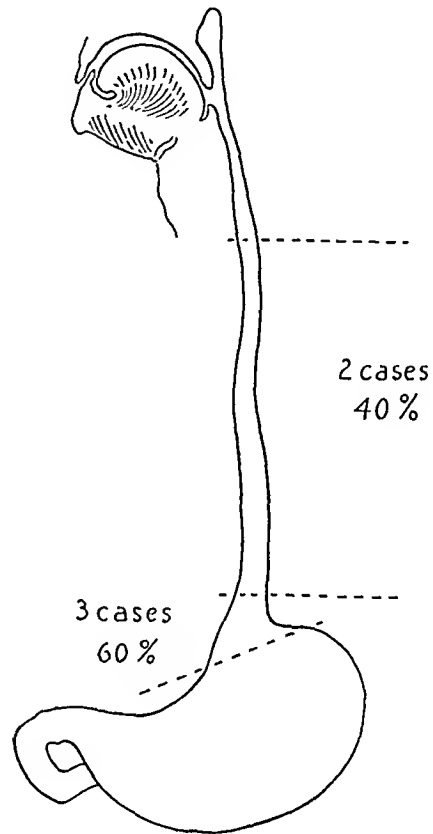


FIG. 4.—Diagram representing distribution of malignant growths for which gastrostomy was performed and worked unsatisfactorily. Note 60 per cent at cardia and 40 per cent above.

There were 13 jejunostomies from 1932 to 1934 for inoperable gastric cancer. Of these, six were of the type described by the author in 1932.⁷ This technic embraces jejuno jejunostomy and a two-barreled jejunostomy. The *temporary* jejunostomy has been found to work well in the acute cases or cases requiring jejunostomy for a short period of time. In these, the muscle-peritoneal flap combined with double inversion about an indwelling catheter and omental grafting has been found advantageous to the more common older methods. The *permanent* method lessens the incidence of postoperative mortality, does away with the fear of having the catheter come out and of the danger of replacing it, and by presenting two openings for

GASTROSTOMY AND JEJUNOSTOMY

TABLE I

*Correlation of Gastrostomy Function and Location of Pathology**

1931				
	Location	Operation	Function	Disposition
1. J. T.	Carcinoma Esophagus Stomach (lesser curvature)	Janeway (L.)	Works well	Discharged 48 days post-operative
2. R. S.	Carcinoma Esophagus (upper $\frac{1}{3}$)	Janeway (mod. W.)	Works well	Discharged 30 days post-operative
3. B. H.	Carcinoma Esophagus (upper $\frac{1}{3}$) O-T fistula	Janeway (B.)	Worked well	Died 12 days postoperative. (Hemoptysis)
4. A. S.	Carcinoma Esophagus (mid. $\frac{1}{3}$)	Janeway (L.)	Works well	Discharged 31 days post-operative
5. H. M.	Carcinoma Esophagus Stomach	Janeway (mod. N.)	Works well	Discharged 31 days post-operative
6. J. M.	Carcinoma Esophagus Stomach	Janeway (L.)	Works well	Discharged 18 days post-operative
7. W. S.	Carcinoma Esophagus (lower $\frac{1}{3}$) Stomach	Janeway (L.)	Worked well	Died 17 days postoperative (pneumonia)
1932-1933				
8. C. J.	Carcinoma Esophagus (mid. $\frac{1}{3}$)	Janeway (B.)	Acute dilation Stomach Regurgitation	Discharged 14 days post-operative
9. W. M.	Carcinoma Esophagus (upper $\frac{1}{3}$)	Janeway (N.)	Works well	Discharged 13 days post-operative
10. J. L.	Carcinoma Larynx Tracheotomy	Janeway (B.)	Works well	Discharged 13 days post-operative
11. C. G.	Carcinoma Nasopharynx Tracheotomy	Janeway (B.)	Works well	Tracheotomy closed. Discharged 72 days post-operative for continued radiotherapy
12. T. C.	Carcinoma Pharynx (rt. tonsil)	Janeway (B.)	Works well	Discharged 17 days post-operative
13. B. H.	Carcinoma Esophagus	Janeway (mod. C.)	Works well	Discharged 2 months postoperative. Radiotherapy
14. M. P.	Carcinoma Stomach Carcinomatosis	Janeway (mod. S.)	Regurgitation	Died 17 days postoperative (perforative gastritis)

TABLE I (*Continued*)

		Location	Operation	Function	Disposition
15.	V. G.	Carcinoma Esophagus (mid. $\frac{1}{3}$) O-T fistula	Janeway (mod. L.)	Worked well	Died 20 days postoper- ative. Lung abscess. Subdiaphragmatic ab- scess. Peritonitis
16.	H. M'C.	Stricture Esophagus	Janeway (B.)	Works well	Seven months' treatment of stricture; then clos- ure of gastrostomy
17.	G. S.	Carcinoma Esophagus (mid. $\frac{1}{3}$)	Janeway (L.)	Worked well (regurgitation)	Died 24 days postoper- ative (pneumonia)
18.	H. S.	Carcinoma Esophagus (mid. $\frac{1}{3}$) O-B fistula	Janeway (mod. C.)	Worked well	Died 25 days postoper- ative (pneumonia)
19.	J. R.	Carcinoma Esophagus (lower $\frac{1}{3}$)	Janeway (mod. C.)	Worked well	Died 11 days postoper- ative (cachexia)
20.	J. B.	Carcinoma Esophagus (lower $\frac{1}{3}$)	Janeway (mod. N.)	Works well	Discharged 30 days post- operative
21.	E. K.	Stricture Esophagus	Janeway (B.)	Works well	Four months' treatment stricture, then gastros- tomy closed
22.	M. R.	Carcinoma Esophagus	Janeway (mod. L.)	Works well	Discharged 57 days post- operative
23.	P. R.	Carcinoma Esophagus (lower 4 cm.)	Janeway (B.)	Works well	Discharged 37 days post- operative
1934					
24.	H. W.	Carcinoma Stomach (lesser curvature)	Janeway (mod. L.)	Pylorospasm. Regurgitation	Discharged 2 months postoperative
25.	P. R.	Carcinoma Stomach (cardia)	Janeway (B.)	Regurgitation	Discharged 13 days post- operative
26.	I. H.	Carcinoma Esophagus	Janeway (B.)	Regurgitation	Died 46 days postoper- ative
27.	E. S.	Carcinoma Esophagus Stomach	Janeway (B.) Vag. Sect.	Worked well	Died 30 days postoper- ative
28.	C. W.	Squamous Cell Epithelioma Nasopharynx	Janeway (B.) Vag. Sect.	Works well	Discharged 11 days post- operative
29.	F. P.	Carcinoma Esophagus (mid. $\frac{1}{3}$)	Janeway (B.) Vag. Sect.	Works well	Discharged 13 days post- operative
30.	J. C.	Carcinoma Larynx Esophagus	Janeway (B.) Vag. Sect.	Works well	Discharged 18 days post- operative
31.	W. L.	Carcinoma Esophagus (mid. $\frac{1}{3}$)	Janeway (mod. L.)	Worked well	Died 10 days postoper- ative (pneumonia)

TABLE I (*Continued*)

	Location	Operation	Function	Disposition
32. E. M.	Carcinoma Esophagus (lower $\frac{1}{4}$)	Janeway (mod. C.)	Works well	Discharged 19 days post-operative
33. J. F.	Carcinoma Tonsil Larynx	Janeway (mod. C.)	Worked well	Died 16 days postoperative

* This table includes two cases of stricture of the esophagus, Cases 16 and 21, and 31 cases of malignancy.

jejunal feeding instead of one, divides up on the traumata of tubal feedings. Jejunostomy combined with jejunostomy provides for the entrance of digestive secretions from the stomach and duodenum into the jejunum below the stoma and does away with the possibility of technical intestinal obstruction. It is generally understood that these cases being of advanced malignancy have practically no life expectancy so that the object of any palliative procedure can be to prolong life but a few days and make these few days more endurable. At the present writing it is believed the Janeway gastrostomy in the pharyngeal and esophageal cases and the permanent jejunostomy for the esophago gastric and certain of the inoperable gastric growths best ensure the desired results.

These operations have been performed by many different surgeons on the Third Division so that the results more typically represent those of general surgical practice in a city hospital. It will be observed that, during 1934, four gastric vagotomies were performed in conjunction with the Janeway gastrostomy. The effect upon gastric function favorably impressed those of us who observed these cases daily, but no conclusions are to be drawn on these few observations at this time.

CONCLUSIONS

(1) Gastrostomy (Janeway) is recommended for carcinoma and obstruction of the pharynx and esophagus.

(2) Gastric vagotomy may be added to gastrostomy for a destructive lesion of the lower half of the thoracic esophagus.

(3) Jejunostomy has been used in this series in inoperable gastric carcinoma not considered entirely hopeless.

(4) Both temporary and permanent jejunostomy has its indications in the inoperable or not primarily resectible ulcers and new growths of the stomach. The technics already published give best results at the present time.

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TORSION AND VOLVULUS OF THE STOMACH WITH DIAPHRAGMATIC HERNIA*

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TORSION and volvulus of the stomach are of engaging interest because of the rarity of the total variety, there being only about 70 cases reported in the literature, the obscurity of the etiology of both total and partial and a growing interest in the diagnosis of the partial and intermittent group.

Great emphasis has been placed by most writers on terminology and classification. Becher states that true volvulus means rotation of the whole viscus between pylorus and cardia, while torsion takes place around the other axis. Von Haberer suggests volvulus mesenterio-axialis and volvulus organo-axialis. All recognize total and partial varieties. In describing them they use interchangeably the terms twisting and rotation. Torsion is derived from the Latin *torqueo* meaning to twist. Volvulus comes from the Latin *volvo* meaning to roll. It seems inconsequential from either a descriptive or etiologic basis whether the stomach twists or rolls itself. Obviously in either case rotation has occurred. It would seem, then, for the sake of accurate description, clarity and simplicity, the term rotation of the stomach be used. We may then describe partial or complete rotation which may be around either the long or transverse axes of the stomach, from right to left or left to right in rotation around the transverse axis, or anterior or posterior in those cases of rotation around the long axis and those that rotate around both axes (Figs. 1, 2 and 3).

Many explanations have been offered as to etiology, but the exact mechanism by which rotation occurs is still obscure. The conditions in which either partial or complete rotation has occurred are well described. In all the cases there has been a lengthening of the mesenteries, particularly the gastrohepatic. This lengthening may be the result of a general ptosis. In congenital abnormalities as in the case reported by Gorell in which there was complete rotation around the traverse axis, the great omentum was only an inch long and did not contain the transverse colon, the transverse colon having a mesentery of its own behind the stomach, the gastrohepatic omentum was five inches long. Diaphragmatic hernia is undoubtedly a predisposing cause as the stomach is drawn upward resulting in lengthening of the mesenteries.

Payer reported 500 cases of diaphragmatic hernia in which there were 12 cases of rotation of the stomach. Bonafé and Poulain report two cases of rotation of the stomach following phrenicectomy, the same mechanism as in

* Read before the Philadelphia Academy of Surgery, November 5, 1934.

ROTATION OF STOMACH

Fig 1—Rotation around the transverse axis
(After Kocher.)

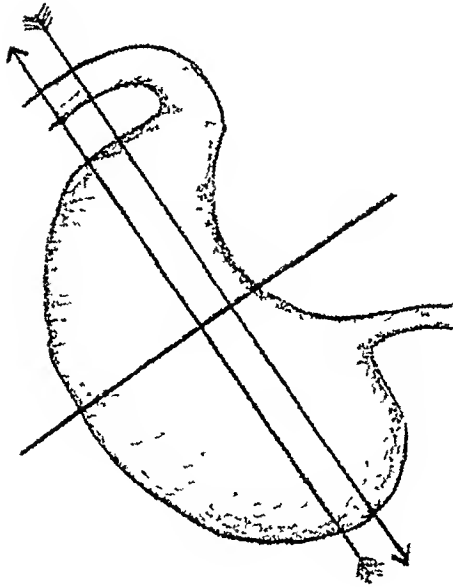


Fig 2—Rotation around the long axis
(After Kocher)

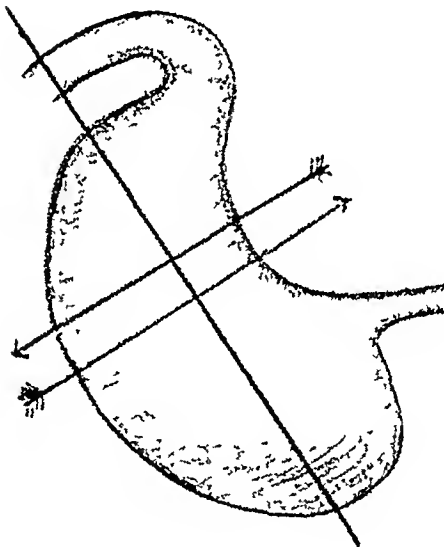
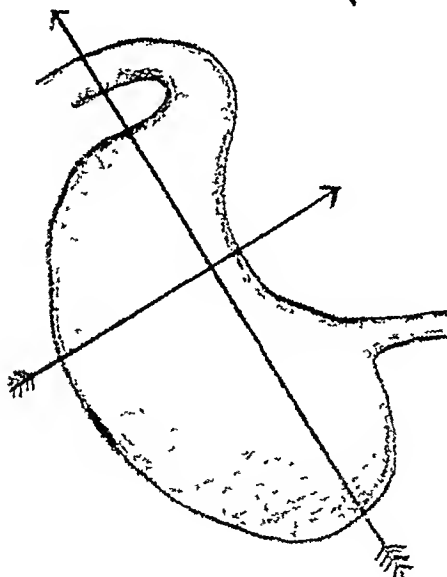


Fig 3—Rotation around the transverse and long
axes as it occurred in this case.



diaphragmatic hernia in all probability operating to lengthen the mesenteries following this procedure.

In the cases of partial rotation some gastric condition, particularly hour-glass stomach, gastric ulcer or gastritis, seems to be present usually. The exciting causes suggested have been overfilling of the stomach, gaseous distention, vomiting, hyperperistaltic waves, weakness of the abdominal wall and trauma.

Diagnosis of partial rotation has been made in several reported cases because of its characteristic symptoms and signs and the roentgenologic appearance. Total rotation should be suggested when there is severe acute abdominal pain with vomiting which suddenly stops followed by retching and immediate abdominal distention and shock. There is inability to swallow and to pass a stomach tube. The diagnosis may be confused with that of a ruptured viscus, intestinal obstruction, acute pancreatitis, mesenteric thrombosis, and coronary occlusion.

Immediate operation is urgently indicated, reducing the rotation and performing a gastropexy. The mortality in complete rotation is about 50 per cent, the percentage being higher in the rotations around the transverse axis.

H. W., married, white male, aged 65, was admitted to the Germantown Hospital on Doctor Swartley's service, July 25, 1934, with the chief complaint of severe pain in the abdomen. He had been perfectly well until 6 P.M. when he ate freely of corn fritters. Acute generalized abdominal pain followed within a few minutes and was very severe. He vomited and then took magnesium sulphate, which he also vomited. After that he could not vomit but retched frequently. The past history revealed that he had had several attacks of "indigestion," the most severe one being last Thanksgiving Day. The patient's appearance was that of profound shock—great pallor with cyanosis and rapid labored breathing. His temperature was subnormal, pulse 150 and respirations 48. The blood pressure was 30/0. The breath sounds over the left chest anteriorly and posteriorly were shallow and occasional râles were heard over the base. The percussion note was flat over the left base posteriorly extending to the fifth rib. The heart sounds were distant but the apex beat did not seem to be much displaced. The abdomen was moderately distended. There was tenderness over the epigastrium and some in the lower right quadrant. Marked increased resistance was found throughout the abdomen, particularly in the epigastrium. No masses were palpable. Peristalsis was absent throughout the abdomen. Hemoglobin 80 per cent; red blood cells, 5,030,000; white blood cells, 17,600; neutrophils, 80 per cent; large lymphocytes, 19 per cent; mononuclears, 1. A specimen of urine was not obtained.

The tentative diagnosis was perforated gastric ulcer; that of coronary occlusion was temporarily entertained. Immediate operation was decided upon, but the patient died before it could be instituted, death occurring six hours after the onset of pain.

Autopsy report by Dr. Frank Lynch. "The left pleural cavity is partly filled with bowel which has herniated through thinned out diaphragm, the left lung occupying about two-fifths of its normal space. The heart is pushed slightly to the right and appears to be slightly smaller than normal. Coronaries are slightly tortuous but soft. The stomach lies in the middle of the abdomen and dilated to such an extent that it reaches almost to the pubic arch. The posterior wall presents anteriorly, the pyloric end to the left and the fundus to the right, with the greater curvature higher than the level of the lesser. By rotating the stomach from above downward and from right to left it falls back into its normal position. It was purplish-brown in color and partly

ROTATION OF STOMACH

filled with liquid material. While the stomach was in the rotated position, the spleen was visible and slightly to the right of the midline. The major portion of the small intestines were above the stomach and some contained within the hernial sac. The cecum was drawn upward toward the liver and a large part of the transverse colon with the omentum were found in the hernial sac. On opening the stomach it was found to be filled with debris, mucus, fluid and a slight admixture of blood. On emptying the stomach, it was found to be thickened, hemorrhagic and covered with a large quantity of thick mucus. The pancreas is widened at the proximal end, the tail is narrow and flabby.

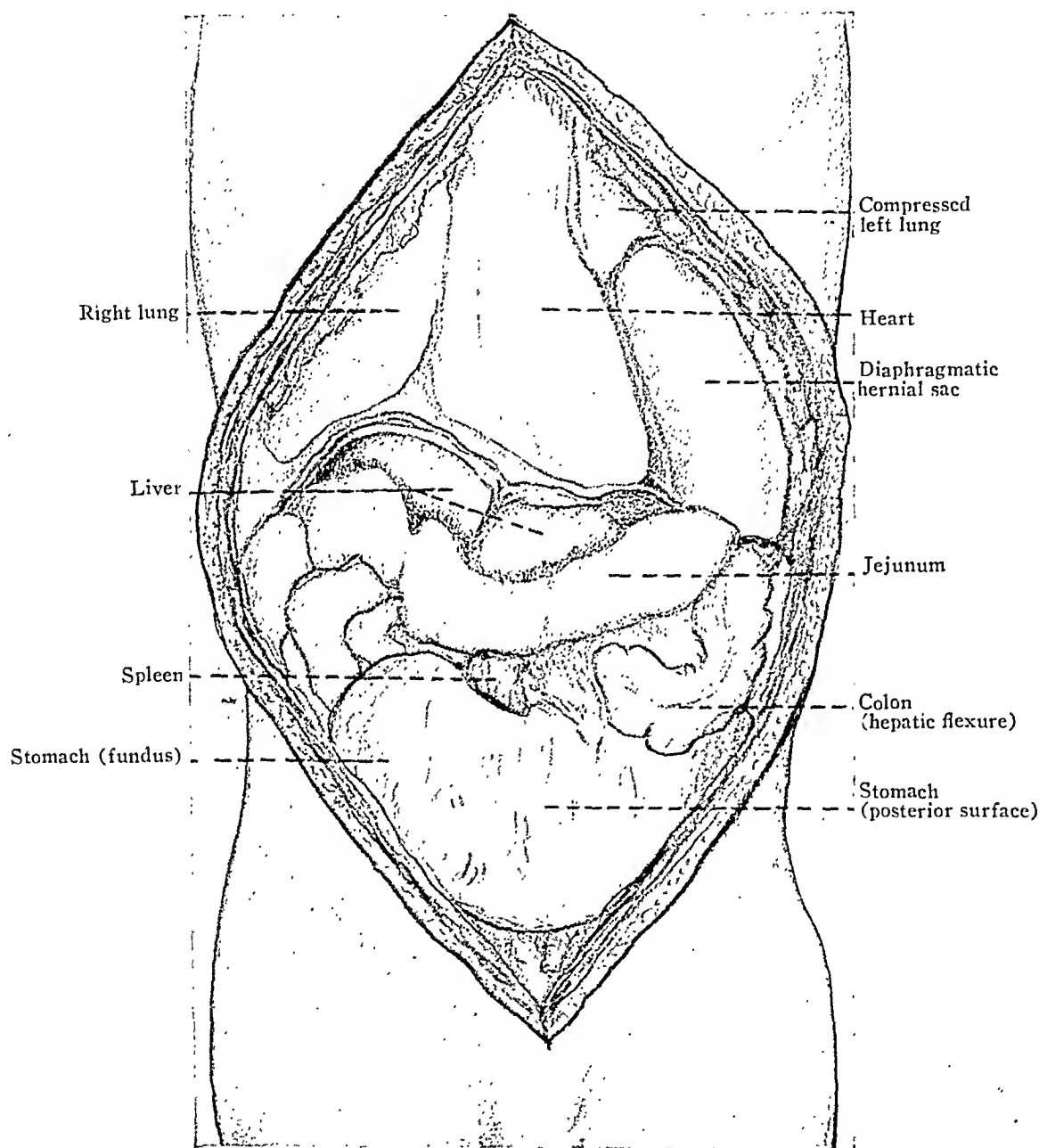


FIG. 4.—Showing the abnormal arrangement of the viscera.

Congestion of the proximal end is due probably to venous stasis. The gastrohepatic omentum is elongated and the duodenum is completely invested with peritoneum forming a mesentery (Fig. 4)."

It will be seen from this description that in all probability the diaphragmatic hernia was the cause of the elongation of the gastrohepatic omentum as the stomach conveniently occupied and adapted itself to the hernial sac when

the intestines and omentum were removed and the rotation of the stomach relieved. Whether or not the duodenal mesentery was formed by traction or was a congenital abnormality cannot be stated. The rotation of the stomach was a complete rotation around both axes, around the longitudinal axis anteriorly and around the transverse axis from left to right. It is interesting to speculate on the exciting cause of the rotation. The fact that the omentum was found well in the hernial sac suggests the possibility that it may have initiated the rotation of the stomach by migrating into the hernial sac, drawing on the gastrocolic omentum which in turn drew the greater curvature of the stomach upward bringing about, together with unusually active peristalsis from overloading the stomach with indigestible food, the resultant rotations.

INVISGERATION*

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CASE REPORT.—F. K., Male, aged 56, was admitted to the Medical Division of Mt. Sinai Hospital, October 31, 1933, with the chief complaint of sense of pressure and of pain in the epigastrium radiating to the right scapula. The onset was about two months earlier, with mild symptoms which became more severe. The pain began after the morning bowel movement and lasted one or two hours, then recurred after the evening meal. It was not very regular nor consistent. Occasionally it was accompanied by vomiting. Relief was obtained by the use of a hotwater bag and by certain powders. There had been a loss of about 30 pounds in a year. The patient had had diarrhea for the last seven years. Appetite was fair; there was occasional pyrosis and belching, but no particular food intolerance. He was treated in the Gastro-Enterological Out Patient Department five years ago, and one year ago, with good results. History was not otherwise significant.

Examination.—The patient was a thin, undernourished man, garrulous and hypochondriacal. General examination showed no abnormalities of any relevance save for an abdomen of ptotic type with a point of tenderness in the right hypochondrium near the midline. Blood count and chemistry, Wassermann, urine and icterus index were within normal limits. Orthodiagram revealed the heart to be normal in position and rather small in size. Gastro-intestinal radiographic study showed a penetrating ulcer of the lesser curvature. Outside of a generally low position of the stomach and colon, the abdominal viscera were visualized as substantially normal.

A diagnosis of gastric ulcer was made and the patient transferred to the Surgical Service of Doctor Eliason, who operated November 16, 1933, through an upper right rectus incision. The peritoneal cavity was entered without difficulty and was found to be *entirely empty*. The cavity was lined with an unbroken membrane having the appearance of ordinary smooth peritoneum. It began above at the transverse fissure of the liver and as the lesser omentum extended to the lesser curvature of the stomach. The stomach was covered by this continuous sheet which was firmly adherent to its anterior surface. From the greater curvature of the stomach the peritoneum extended in an unbroken sheet down to the promontory of the sacrum, whence it passed anteriorly in the horizontal plane to the anterior abdominal wall and became continuous with the anterior parietal peritoneum. Thus it was impossible to introduce the exploring hand into the true pelvis. This peritoneal sheet extended unbroken to both lateral abdominal walls and was continuous with their parietal peritoneum. Beneath it could be seen the great omentum overlying all the intestine except a few coils of small bowel in the left lower quadrant. Nowhere did any portion of the intestine, large or small, project through it into its cavity. It was not determined definitely whether any of the subjacent bowel was adherent to it, but its smooth unwrinkled appearance made this appear improbable.

The stomach was carefully examined and no evidence of ulcer found. The abdomen was then closed without further investigation. The patient made an uncomplicated convalescence, and when seen in the follow up clinic stated that he had only occasional abdominal discomfort, but that his tendency to diarrhea continued.

In order that the various theories entertained as to the nature and causation of the condition described be clear, a brief summary of the develop-

* Read before the Philadelphia Academy of Surgery, November 5, 1934.

ment of the peritoneum may be given. The peritoneum develops from the mesenchyme. The portion of it covering the abdominal wall requires no description. The mesenteries and visceral peritoneum are formed from the anterior and posterior primary mesenteries. The former extends in the sagittal plane from the anterior surface of the upper portion of the gut-tube to the anterior wall only as far down as the umbilicus, and carries in its free edge the umbilical vein. In adult life it forms the peritoneal covering of the liver and its falciform ligament, as well as the lesser or gastrohepatic omentum. With the rotation of the stomach the anterior mesentery changes its axis from the vertical to the horizontal and is drawn to the right.

The posterior mesentery, usually called the mesogastrium, extends in early fetal life from the posterior surface of the gut-tube to the anterior surface of the aorta. It is this mesogastrium which later forms the great omentum, transverse mesocolon, mesosigmoid, mesentery of the small intestine and the visceral peritoneum. Its development and relations, including as they do the formation of the lesser peritoneal cavity and the numerous peritoneal fossae, are too complex to be described in this short presentation. It may be mentioned, however, that the great omentum is in fetal life, and sometimes at birth, an open sac communicating with the lesser peritoneal cavity, and that at this time it depends directly from the greater curvature of the stomach. At about the time of birth or shortly thereafter, its anterior and posterior leaves fuse with each other. This results in the obliteration of the so called omental bursa, the formation of the gastrocolic omentum, and the attachment of the great omentum to the transverse colon.

Various possible explanations of the situation found in our patient are to be considered. Diaphragmatic hernia may be discarded at once for the obvious reason that there was no evidence of its existence. A more plausible theory is that of intraperitoneal hernia. This is a condition of no great rarity, in which much or indeed most of the intestine finds its way into one of the numerous peritoneal fossae and comes to be retroperitoneal in appearance at least. When the abdomen is opened the cavity may seem to be empty, but closer investigation will always show at least a portion of intestine, either small, large or both, to lie free within it. This was not true in the present instance and therefore hernia into a peritoneal fossa is excluded.

Cases have been recorded in which there was double anterior peritoneum. This, however, has always been of limited extent, usually in either the right or left lower quadrant, and a potential cavity only in that the two layers lay apposed. Furthermore, when the deeper of these layers has been penetrated, the ordinary intra-abdominal relationships obtain. It has been suggested, likewise, that the true peritoneal cavity may not have been entered in our case, but that only the cleavage line between the transversalis fascia and the peritoneum may have been reached. This hypothesis is effectually excluded by reason of the facts that the free edge of the liver could be seen and that the hand could be passed down to the sacrum, though not beyond it.

Another theory, based upon a mechanism analogous to that by which the second and third portions of the duodenum become retroperitoneal, has

been advanced. For various reasons it may be discarded. Among these is that it is incompatible with the existence of a great omentum and that the abdominal viscera not completely covered by peritoneum are adherent to the posterior abdominal wall. It is hardly conceivable that the entire intestinal tract should be so adherent.

A final concept is that we are dealing with an extraordinary omental bursa, that is, a persistence of the fetal condition of nonfusion of the anterior and posterior layers of the great omentum. In addition, we must postulate, in order to fulfill the conditions found at operation: (a) a fusion of the anterior layer of the great omentum with the anterior parietal peritoneum at a point a short distance below the greater curvature of the stomach; (b) a loss of the fatty and vascular character of this layer; (c) an attachment of the omentum to the lateral abdominal walls so as to form a complete septum and to the promontory of the sacrum below; (d) an assumption by the anterior surface of the posterior layer of the omentum of the characteristics of ordinary peritoneum and the disposal of the fat and blood vessels upon the posterior layer; (e) that the incision traversed the anterior layer of the omentum as the latter passed from the greater curvature to the abdominal wall.

Of these postulates, that concerned with the existence of an omental bursa and that which provides for the attachment of the omentum to the lateral abdominal walls are not without precedent. As regards the remaining ones, no precedent has been found for the fusion with the anterior wall; the suggested alteration in the arrangement of the omental fat seems to be inconsistent with the known anatomy of the omentum; and finally, the incision was not observed to traverse an anomalous layer of peritoneum between the greater curvature and the anterior parietes.

It is now apparent that no tenable explanation for the findings in this case has been offered. Not only is this true, but upon the accepted facts of the embryology and anatomy of the peritoneum we have been unable to construct one. A search of the literature has not yielded either an identical or a comparable case. Whether our failure to provide an answer to our riddle is due to faulty or incomplete observation, or to a hitherto undescribed anomaly is of course an open question. Pending enlightenment we have tentatively suggested the name "Invisceration" and are reporting the case in the hope that it may provoke discussion which will dispel what to us is an unsolved mystery.

DISCUSSION.—DR. BENJAMIN LIPSHUTZ (Philadelphia) said that a sound and tenable explanation of this extremely rare peritoneal anomaly presented by Doctor Goldsmith, under the title "Invisceration," is best obtained by a consideration of certain well established embryologic conditions. For there is nothing here to indicate that the anomaly might have been the result of a pathologic condition. All of the special features suggest an early embryologic origin of this anomaly. In order to accurately interpret such an anomaly it is necessary to make careful observations of the various peritoneal attachments, to note displacements of viscera, and the related blood supply. Such observations are possible only at autopsy or in the dissecting

room. Variations in the rotations of the bowel are well known—an instance of non-rotation or faulty rotation was reported by Doctor Klopp, before this society some years ago; peritoneal invisceration, on the other hand, is an entirely different anomaly. The explanation which would seem to best clarify the reported case of invisceration is that advanced by James W. Papez of Cornell.

This anomaly is interpreted as one of early embryonic origin, by assuming that the abnormal peritoneal sac was derived from the normal embryonic umbilical hernia, which encloses the small intestines prior to the 30 Mm. stage of the embryonic growth. The bowel in the embryonic normal umbilical hernia grows and develops and produces bulbous enlargement of the proximal end of the cord. The umbilical hernia is lined with peritoneum which is continuous with the peritoneum of the abdominal cavity. It is believed that the neck of the sac at the umbilical orifice becomes prematurely adherent to the duodenum by virtue of close opposition, which exists between them at this early stage of development.

The retracting forces which suddenly draw the intestines into the abdominal cavity also draw in the peritoneum of the early embryonic cavity, in case an adhesion happens at the umbilical orifice. Within the abdominal cavity, the small intestine grows, expanding the sac to its adult dimensions.

When such cases are encountered by the surgeon, particularly if the incision is made on the right side of the abdomen and the condition present is a right paraduodenal hernia the operative findings may appear as an apparent complete invisceration of the abdominal contents, since the colon is situated to the left side of the abdominal sac. The sac gives the impression of being extraperitoneal as far as the general peritoneal lining is concerned. The similarity between such invisceration and the better known paraduodenal herniae deserves mention.

Papez is also of the opinion that right and left paraduodenal (or retroperitoneal) herniae in the vast majority of instances probably arise in this manner and not as has been postulated by Moynihan and others by insinuation of the gut or inclusion under one of the paraduodenal fossae or folds. The small intestines in the majority of cases are the only structures enclosed in the special peritoneal sac which is suspended either from the transverse colon or the region of the duodenum, the former being the most common condition (left paraduodenal hernia). It seems that the right and left paraduodenal herniae and their surrounding sac have a more natural origin in the very early embryonic umbilical hernia. All told, about 34 cases of right and 105 cases of left paraduodenal herniae have been recorded. This interpretation assumes an identical origin for both right and left herniae from the early umbilical peritoneal sac. In case the large intestine has completed its rotation to the right of the sac, across the duodenum and mesenteric root before adhesion of the orifice of the sac and retraction of the gut has taken place, it would result in the more common form or left paraduodenal hernia, in which the abnormal sac is situated to the left of the ascending colon and is suspended from the transverse colon and its mesentery. In case the large intestine has not completed its rotation before adhesion of the orifice of the sac and retraction of the gut has taken place the condition produced would be a right paraduodenal hernia, in which the abnormal sac is situated to the right of the ascending colon.

The case reported by Doctor Goldsmith may reasonably be interpreted as a right paraduodenal hernia. In the more common left paraduodenal hernia the abnormal sac with the contained bowel lies between ascending and descending portions of the colon suspended above from the transverse colon.

PNEUMOCOCCUS PERITONITIS

AN ANALYSIS OF SEVEN CASES

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ABOUT 2 per cent of abdominal emergencies in childhood are due to pneumococcus peritonitis (McCartney and Frazer¹¹). About 75 per cent of all cases of pneumococcus peritonitis occur in females under ten years of age (Blake²). About 0.24 per cent of cases of pneumonia develop pneumococcus peritonitis (Rolleston¹⁵). Most cases seen in girls are of the primary type. Most cases seen in boys are secondary in type. Less than one-third of all cases are secondary cases.

Pathology.—In the first stage of the disease there is no true pus. A thin, serous, turbid, odorless liquid, creamy or grayish yellow in color, is to be observed. Diffuse pus is formed in the intermediate stage. The peritoneum is not always markedly reddened. It has a slippery, slimy feel. A thick fibrinous exudate with the formation of adhesions and abscesses usually situated in the lower abdomen is encountered in the third stage. These abscesses may perforate spontaneously through the umbilicus. The third stage usually appears about the fourth day or thereafter. Coexistent pneumonia, pleurisy or pericarditis are common in cases of general pneumococcus infection.

Symptoms and Differential Diagnosis.—The symptoms may be violent or fulminating, with hyperpyrexia, cyanosis, rapid pulse and prostration. One of McCartney and Frazer's cases died within 36 hours. There may be excessive vomiting during the early acute stage which cannot be confused with the vomiting of obstruction because of its early appearance.

The facies are quite normal in the initial and progressive stage but Hippocratic facies may be seen in the third stage. This is a frequent sign. Pain is frequently complained of in the left lower quadrant instead of the right lower quadrant and midabdomen. Diarrhea is observed in the early stage, especially in the primary infections. It does not occur so frequently in the secondary type; males are more usually affected. The diarrhea is usually relieved. Tenesmus and blood-stained mucus sometimes occur. Frequent painful micturition may be distinctive.

Distention in the upper abdomen with tenderness and rigidity confined to the lower abdomen is the usual finding upon physical examination. Digital rectal examination should be made. The presence of an early mass may be determined.

Many authors have put a great deal of emphasis upon the fact that most cases present a high leukocytosis. The average count in our cases was

22,000. This is somewhat higher than the average count which one finds in acute appendicitis. Still, it is comparable to what might be expected in other types of peritonitis. Too much confidence, therefore, should not be placed in this finding.

One diagnostic point of great clinical value is the aspiration of the peritoneal cavity through a small needle. The diagnosis is rather definite if we find creamy odorless pus containing Gram-positive extracellular diplococci.

Prognosis.—Many writers are pessimistic regarding the prognosis. Rischbieth¹⁴ found a mortality of approximately 90 per cent. McCartney and Frazer¹¹ report 65 per cent mortality. Later cases treated in their group in 1921 showed a reduction to 42 per cent. Ciminata⁴ reported a mortality of 50 per cent in a group of eight cases.

Treatment.—The latest statistics show controversial opinions. The majority of authors favor late intervention. McCartney and Frazer advise early drainage subsequent to blood transfusions. They claim a reduction in the mortality from 65 to 42 per cent. Leipshutz and Lowenburg⁸ likewise agree to early operation because they believe it is impossible to differentiate this type of peritonitis from other forms. Montgomery¹² and Schwartz also advocate early operation. Ombredanne,¹³ who has had an extensive experience in infant surgery, believes operation should be done without delay.

Auroseau,¹ Loewe,¹⁰ Budd,³ Davioud and Mathieu⁵ have had a mortality varying between 75 to 95 per cent after premature intervention. Budde³ and Salzer¹⁶ have obtained a lowered mortality in the late stages of 6 to 25 per cent. Elkin⁶ and Kahn⁷ favor operation in the late stage. Lilenthal⁹ believes these patients, like cases of gonorrheal peritonitis, should never be treated by operation. Ciminata⁴ prefers to operate in the third stage. All of his cases were of the primary type. Two were operated upon in the first stage and two in the second stage. These four cases died. Four cases were operated upon in the third stage. All of them recovered.

Five of the seven cases herewith reported were of the secondary type. Three recovered. Operation had been delayed from nine days to several weeks after the onset of symptoms. The two cases of the secondary group which died were operated upon during the intermediate period. One of these had a perforated gangrenous appendix with a mixed infection of Gram-positive bacilli and pneumococci.

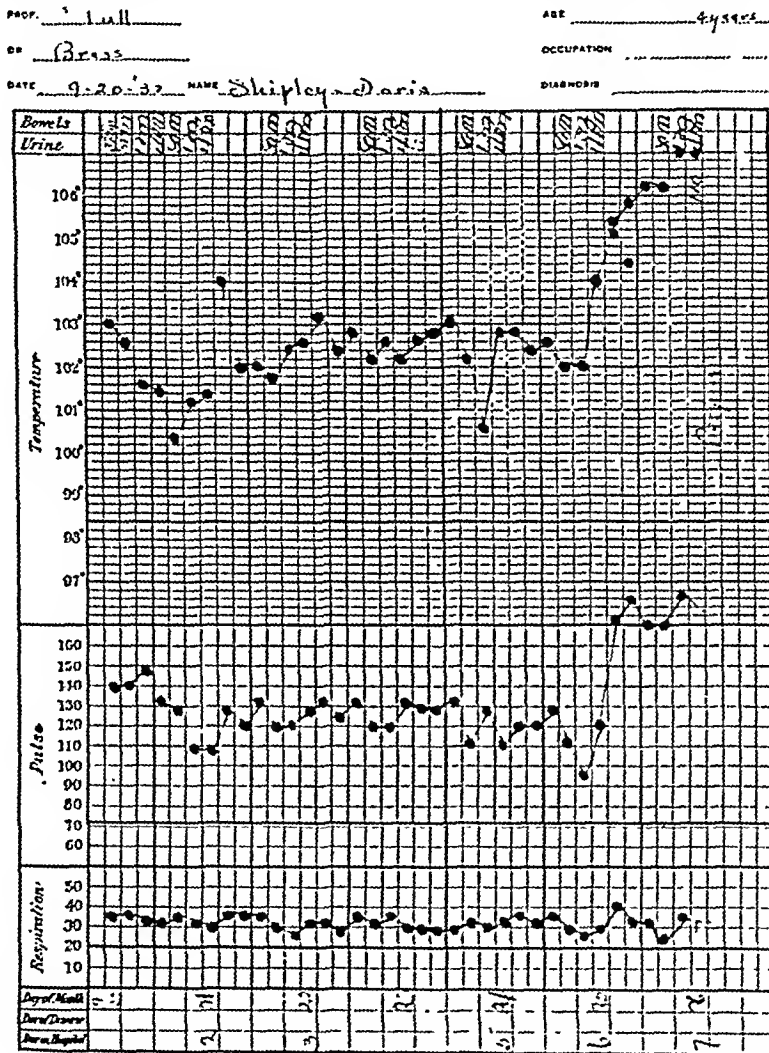
TABLE I

No.	Age	Sex	Duration of Illness		Primary Infection	Result
			Prior to Operation			
1	32	M.	2 days		Acute gangrenous appendicitis	Died
2	15	F.	4 days		Bronchopneumonia	Died
3	9	F.	9 days		Bronchopneumonia	Cured
4	5	F.	14 days		Abscess of shoulder	Cured
5	5	M.	Several weeks		Bronchopneumonia	Cured
6	16	F.	7 days		Tuberculous peritonitis	Died
7	4	F.	6 days		Gonorrheal vaginitis	Died

Two cases of our group were of the primary type. One was operated upon six days after the onset of symptoms. The other patient, a colored girl, 16 years of age, had pneumococcus peritonitis complicating tuberculous peritonitis. She was operated upon seven days after the onset of acute symptoms (Table I).

The abdominal cavity was drained in each instance by abdominal section. Two patients were of sufficient interest to justify a short abstract of their record.

CASE VI.—F. B., colored, female, aged 16 years, was admitted to the University Hospital January 22, 1932. She gave a history of "feeling bad for one week." Acute,



GRAPH 1.—Showing range of T. P. R. in Case VII, indicating the advisability of waiting to operate late in these cases.

violent pain persisted for 24 hours prior to admission. The pain began during the act of micturition. There was no nausea or vomiting. The abdominal examination showed marked diffuse rigidity. She was more tender in the lower right quadrant. The tip of the cervix was soft and a boggy mass was found to the right of the uterus. The patient was operated upon January 23, 1932. A large pelvic abscess was drained through a midline incision under ether anesthesia. The patient died on February 5, 1932. An autopsy disclosed a disseminated tuberculous and pneumococcus infection of the peritoneum.

CASE VII.—D. S., white, female, aged four, was admitted to the Sydenham Hospital

June 28, 1933. The past history was positive for measles, chicken pox and whooping cough. The diagnosis was gonorrheal vaginitis. She was discharged July 24, 1933—condition improved. The patient reentered the Sydenham Hospital September 20, 1933. Temperature 103°, pulse 140 and respirations 35. A purgative had been given before admission. She pointed to the lower left quadrant when questioned about abdominal pain.

Physical examination showed marked abdominal distention with rigidity and tenderness in the lower half. Hippocratic facies were absent. The face was flushed but the child did not appear to be ill. Diarrhea persisted for several days. The blood cell count showed 17,500 leukocytes with 92 per cent polys. The following day 23,600 with 96 per cent polys. The radiogram showed a negative chest. A rather large mass developed in the midline of the lower abdomen five days after admission and vomiting recurred on that date.

Discussion.—I believed that the patient had been suffering from gonorrheal peritonitis notwithstanding the high cell counts. On September 25, six days after the onset of acute symptoms, the patient had a recurrence of vomiting. The diarrhea had subsided and enemata were effectual. It was decided to operate upon her and a small amount of odorless pus escaped from the right McBurney incision. No attempt was made to explore the abdomen or abscess cavity. Several drains were placed in the wound. The patient returned to the ward in good condition. She immediately became worse and died within 24 hours. Autopsy revealed pneumococcus peritonitis.

I think we would have been justified in aspirating the peritoneal cavity to prove the diagnosis in this case. The pulse rate (the best prognostic guide in peritonitis) appeared as though it had a tendency to subside on the date of operation. A better protective barrier might have been formed if the operation should have been delayed several days longer. We believe the course of the charted pulse rate is a valuable subsidiary index which may be used to determine the proper time for operation.

Operative intervention prior to the formation of encysted peritonitis will lead to disaster and continued high mortality in this condition.

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PENETRATING WOUNDS OF THE ABDOMEN*

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THIS analysis of penetrating stab and gunshot wounds of the abdomen comprises 164 cases treated at the Harlem Hospital, New York, from March, 1930, to January 1, 1935, under the direction of the late Dr. John Fox Connors.

In comparison with other hospitals in New York City, Harlem Hospital receives many of these cases. Because of a breakdown and change in system in the record room, it was necessary to start this present series in March, 1930.

There were 100 cases of penetrating stab wounds of the abdomen with 21 deaths, a mortality of 21 per cent. There were 64 cases of penetrating gunshot wounds of the abdomen with 38 deaths, a mortality of 59.3 per cent. The total number of deaths in the two series was 59, a combined mortality of 35.9 per cent.

The two groups are considered separately, because the stab wounds on the whole are less serious than the gunshot cases, by reason of the more limited range of the knife blade. In the gunshot cases there is apt to be more hemorrhage and more extensive visceral injury.

In this series, as in others, the usual ratio of the greater severity of the gunshot over the stab injuries was maintained, that is, a little more than two to one. A brief review of the published statistics will show that the operative mortality in civil life seems to have been established around 50 per cent for gunshot wounds, and around 25 per cent for penetrating stab-wound injuries.

The New Orleans Charity Hospital statistics on penetrating abdominal gunshot injuries show 1,299 cases as having been treated at that institution in 32 years (1900-1931), with a mortality of 62.3 per cent.

Wallace,¹ reporting 1,200 gunshot cases from the British Expeditionary Force, showed an operative mortality of 53.9 per cent, and a total mortality, including nonoperated cases, of 60.2 per cent. Lockwood, Kennedy, *et al.*,² in military service, reported 500 cases with an operative mortality of 51.9 per cent. Mason⁴ analyzed 127 cases and emphasized the influence of hemorrhage on mortality, dividing his series into large and small hemorrhage groups, regardless of visceral injury, with a mortality in the large hemorrhage group of 87.2 per cent, and one of 36.1 per cent in the small hemorrhage group.

Billings and Walkling,⁶ in a comprehensive study of 220 cases of penetrating wounds of the abdomen admitted to the Pennsylvania Hospital

*Read before the New York Surgical Society, May 8, 1935.

over a period of 21 years, reported an operative mortality of 22 per cent in stab wounds and 48 per cent in gunshot wounds. These writers, and also Winslow,³ in a report of 31 cases treated at the University Hospital in Baltimore with 16 recoveries and 15 deaths, noted the importance of injuries overlooked at the time of operation. More recently, Prey and Foster⁷ have reported 22 cases of gunshot wounds admitted to the Denver General Hospital, from 1928 to 1933, with a mortality of 68 per cent.

These patients as a group are usually active, robust individuals, the greatest number being between the ages of 20 and 40. In this series of 164 cases, 129 were in this age group. Most writers have pointed to the high proportion of colored patients in their series. In this group of 164 cases, there were 127 colored patients (Table I). While not noted in the individual cases, alcoholic intoxication was an accompanying factor in many patients.

TABLE I

PENETRATING WOUNDS OF THE ABDOMEN

From March, 1930, through December, 1934

Total number..... 164
Mortality..... 59, or 35.9 per cent

Stab Wounds—100 cases

91 males..... 85 were colored
9 females

There were 21 deaths in the series, or 21 per cent

Gunshot Wounds of Abdomen 64 cases

57 males..... 42 were colored
7 females

There were 38 deaths in this group, or 59.3 per cent

AGES

	Gunshot	Stab
1-10.....	0	0
10-20.....	7	2
20-30.....	26	45
30-40.....	23	35
40-50.....	6	13
50-60.....	1	5
60-70.....	1	

In 79 surviving penetrating stab wounds of the abdomen, there were 16 cases of penetration of the abdominal wall and parietal peritoneum but no visceral injury. Subtracting these cases, we have 63 cases with 21 deaths, or a revised mortality of 33.3 per cent.

It seems to the writer that a more accurate comparison between the severity of stab and bullet wounds may be made if the above type of case is not considered in figuring the mortality of stab wounds. True, they come under the classification of penetrating wounds but they are not accompanied

by any visceral injury—a happening not uncommon in stab wounds but quite unusual in bullet wounds of the abdomen.

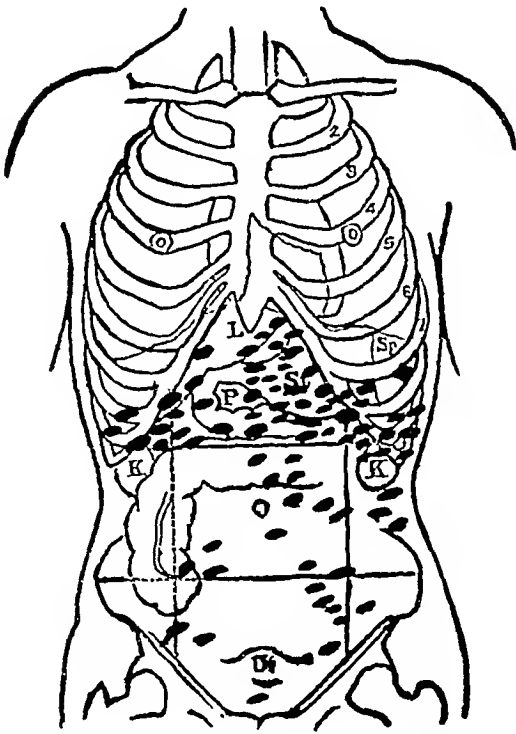


FIG. 1.—Location of stab wounds (surviving).

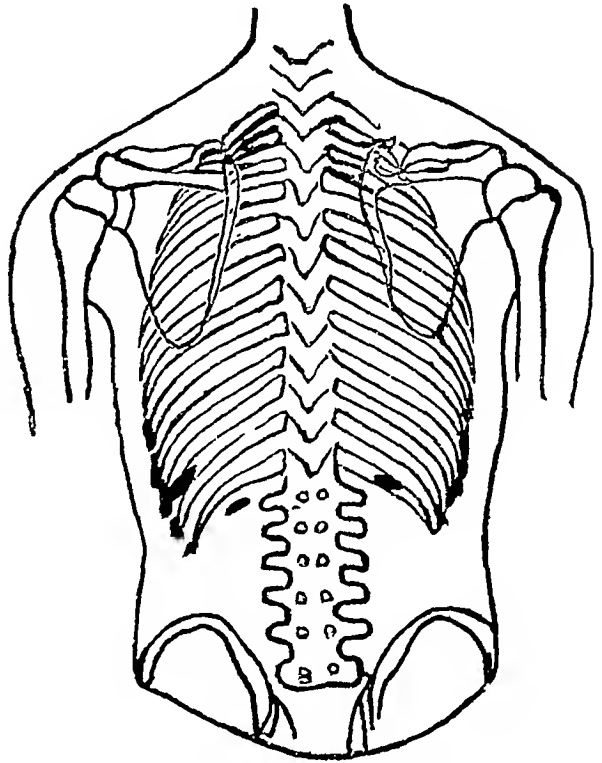


FIG. 2.—Location of stab wounds (surviving).

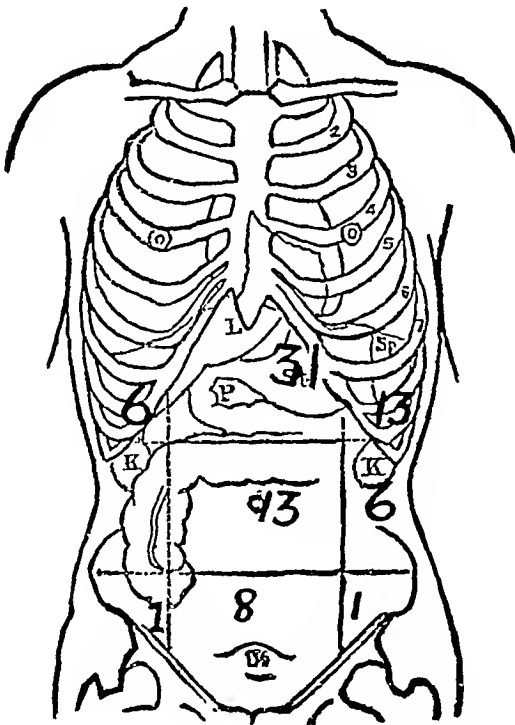


FIG. 3.—Location of stab wounds (surviving).

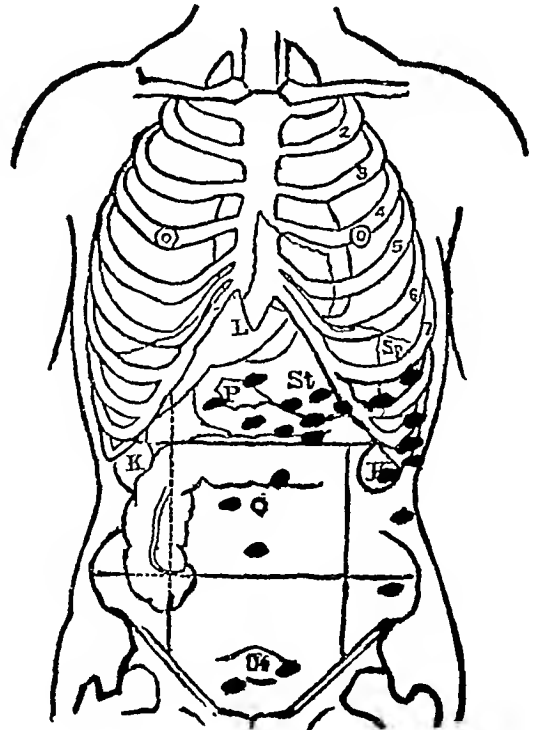


FIG. 4.—Location of stab wounds (fatal cases).

There were 21 cases presenting penetrating stab wounds of the abdomen with evisceration of omentum. In nine of these the injury was confined to the omentum (Table II).

TABLE II

Cases of Evisceration of Omentum with Associated Injuries

	Liver	Costophrenic Sinus	Small Intestine	Stomach	Diaphragm	Retroperitoneal Hematoma
1.	X	X			X	
2.			X (2)			
3.				X		
4.	X					
5.				X (serosa)		
6.			X			
7.				X		
8.			X			
9.				X		
10.		X		X (serosa)	X	
11.				X		
12.			X (2)			X

There were 17 cases of penetrating stab wounds with evisceration of major degree (Table III).

TABLE III

Injuries

Evisceration (17 cases)	Stom- ach	Spleen	Small Intes- tine	Large Intes- tine	Dia- phragm	Liver	Retroperi- toneal Hematoma
1. Omentum, small intest.		X					
2. Omentum, small intest.			X				
3. Greater part of small and large intest.			X (5)				
4. Stomach trans. colon, omentum	X (serosa)						
5. Loop of small intest.							
6. Complete evis- ceration			X (serosa)				
7. Complete evis- ceration							
8. Small intestine			X (serosa)				
9. Colon, spleen, omentum				X (2)	X		
10. Small intestine			X (6)				
11. Trans. colon, omentum, small intest.						X	
12. Stomach, omen- tum	X						
13. Small intestine							

TABLE III—(Continued)

14. Small intestine, omentum		
15. Small intestine	Loop strangu- lated]	
16. Hepatic flex., colon, small int.		
17. Small intest.	X (serosa)	X

There were 25 stab wounds (1 case not operated upon) without evisceration but with the following intra-abdominal injuries (Table IV).

TABLE IV

Injuries in Cases of Penetrating Stab Wounds without Evisceration

	Blood	Liver	Stomach	Spleen	Gallbladder	Small Intestine	Retroperitoneal Hematoma
1. ++++		X					
2. +++		X					
3.			X (serosa)				
4.		X					
5. ++++			X (2)	X			
6.					X (2)		
7.						X	
8.			X				
9. +++		X					
10. +							X
11. +			X (serosa)				
12. ++		X					
13. ++			X (serosa)				
14.							X
15. ++		X					
16.		X					
17. ++		X					
18.							X
19.		X					
20.			X				
21.						X	
22.			X				
23. +++		X					
24.		X					

It is important to note that in this group of 79 surviving cases of penetrating stab wounds of the abdomen, only five cases presented retroperitoneal hematomata, one case presented a double penetrating wound of the large intestine (anterior wall) and one case presented a serosal wound of the large intestine.

There were no cases of injury to the duodenum, pancreas, extraperitoneal portion of large intestine or rectum. No case presented extensive retroperitoneal hemorrhage. Outside of controlling hemorrhage by packing (in liver wounds) there was, in general, no indication for intraperitoneal drainage in this series.

TABLE V
Fatal Stab Wound Cases

Evisceration	Blood	Large Intestine	Small Intestine	Stomach	Liver	Costophrenic Sinus	Spleen, etc.	Dia-phragm	Retroperitoneal Hematoma
1. Bleeding omén.	+++								
2. Omentum.	+++	X	X						
3.	+++	X							
4. Omentum.				X					
5.	+++				X				
6.	+++					X	X (Ass. head injury)		
7. Omentum.				X (2)					
8.	+++		X (serosa)	X (serosa)					
9. Omentum.		X (2)		X					
10. Colon.						X		X	
11. Omentum.			X (2)						
12.	+++			X (serosa)					
13.	+			X					
14. Omentum.				X (2)					X (P. M. R. R. artery cut across)
15.									X
16. Small intest.			X						
17. Trans. colon, small intest. omentum.					X				
18.	+++		X (6)						
19.							(Ass. chest inj.)		P. M. Left hemothorax
20. Half of gastro-intestinal tract, omentum.						X	(Ass. chest inj.)	X	P. M. Rt. hemothorax (diaph. and liver)
21. Small intest.	+++	X	X (2) X (3)						

We can readily group the causes of death in the cases of fatal penetrating stab wounds as follows: hemorrhage, 12 cases; suppurative peri-

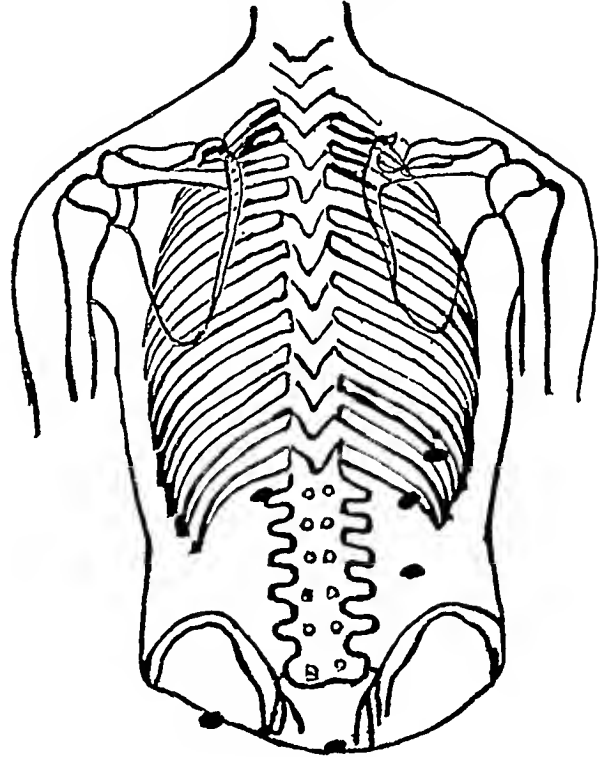
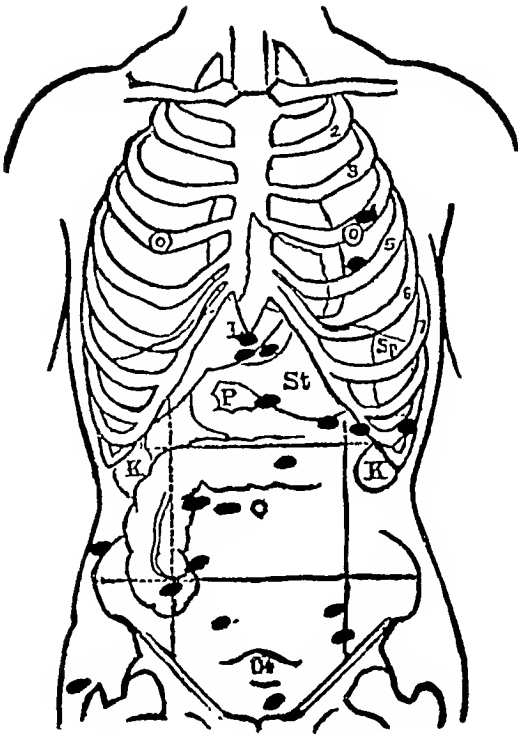


FIG. 5.—Bullet wounds of entrance (surviving).

FIG. 6.—Bullet wounds of entrance (surviving).

tonitis, five cases; intestinal obstruction (with volvulus), one case; acute pneumonia, two cases; pylephlebitis (? liver abscess), one case. Thus in

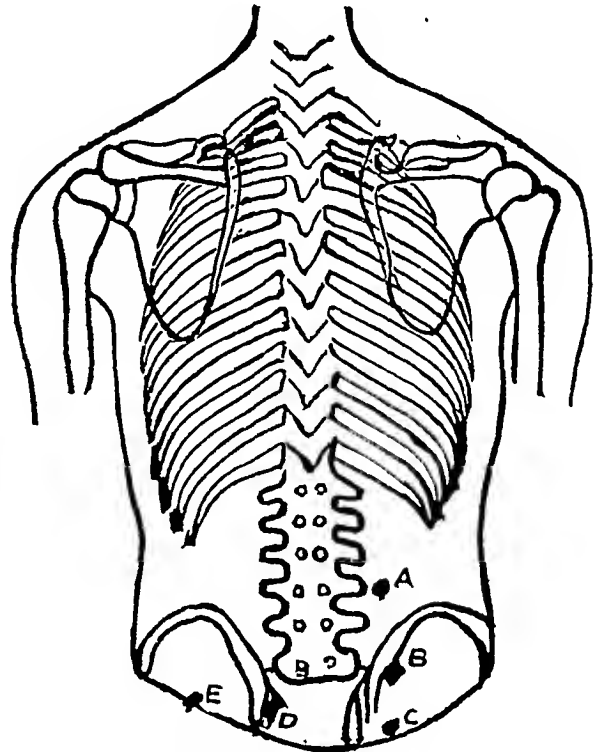
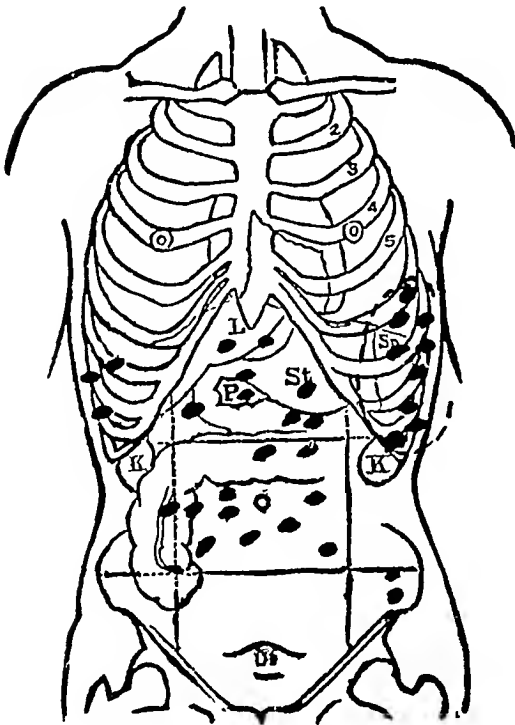


FIG. 7.—Bullet wounds of entrance (fatal cases).

FIG. 8.—Bullet wounds of entrance (fatal).

17 cases, or 80.9 per cent of total deaths, it was due to hemorrhage in 12 and suppurative peritonitis in five instances. Nine cases died within 24

TABLE VIII
Lesions in Surviving Gunshot Cases

	Time in Minutes from Injury to Operation	Small Intest.					Liver	Stomach	Gallblad- der	No. of				Kidney	Spleen	Retroperi- toneal Hematoma	Associated Injuries
		Shock	Blood	Liver	Stomach	Gallblad- der	Small Intest.	Large Intest.	Omentum	Rectum	Bladder	Meso	Serosa				
1.	120	+	++	+	+	+			+								
2.	60	+	++		+												
3.	330	0	++														
4.	300	0	++					+								+	
5.	360		++													+	
6.	120		++	+		+											
7.																	
8.	90	0	+	++													
9.	180	0	++	+													
10.	180		++		+												
11.	60		++													+	
12.	480	+	++	+	+											+	
13.	105		+		+												
14.		0	+														
15.	120		++														
16.	180		++		+												
17.	120		++														
18.	180	0	++	+													
19.	165	+	++														
20.	150	+	++														
21.	60	+	++	+												+	
22.	150		++														
23.	120	0	++														
24.	480		++														
25.	150		++														
26.	1020		++	+													

PENETRATING WOUNDS OF ABDOMEN

hours, five within the first week, and the seven others ranged from 13 to 43 days (Table V).

There were a total of 64 cases of penetrating gunshot wounds of the abdomen with 38 deaths, or a mortality of 59.3 per cent.

Surviving Cases.—Time elapsing between injury and exploration 1 hour to 17 hours, an average time of 3.6 hours. Definite shock was noted in six cases on admission. When the amount of hemorrhage was noted, it was estimated as large in 10 cases and moderate in 11 cases.

TABLE VI

Penetrating Bullet Wounds of Abdomen

	Surviving Cases 26	Fatal Cases 38
Time elapsing bet. injury and exploration	3.6 hours	3.7 hours
Clinical shock was noted as present on admission in —	6 cases, or 23%	31 cases, or 81.5%
When the amount of hemorrhage was noted it was noted as —	large in 10 cases, or 38.4% moderate in 11 cases, or 42.3%	large in 23 cases, or 60.5% moderate in 7 cases, or 18.4%

TABLE VII

Visceral Lesions

Liver.....	8	Small intestine.....	8
Retroperitoneal injury (hemor.).....	7	Omentum.....	2
Stomach.....	5	Diaphragm.....	2
Large intestine.....	5	Spleen.....	1
Rectum.....	3	Pleura.....	1
Urinary bladder.....	2	Gallbladder.....	2

Analysis of Fatal Cases.—In 38 cases, autopsies were done on 27 (71 per cent). Five cases died on the operating table (autopsies on two of these). Time elapsing between injury and exploration, one hour to ten hours, with an average time of 3.7 hours. Excluding the five cases that died on the operating table, the survival times ranged from one to 13 days postoperative, with an average survival of 3.7 days. Definite clinical shock or collapse was noted in 31 cases on admission. When the amount of hemorrhage was noted, it was estimated as large in 23 cases and moderate in 7 cases. Lesions were missed in 15 cases (Table IX).

TABLE IX

Lesions Overlooked

Liver.....	4 times	Pancreas.....	2 times
Large intestine.....	2 times	Pleura.....	2 times
Rectum.....	2 times	Diaphragm.....	3 times
Kidney.....	3 times	Lung.....	1 time
Duodenum.....	1 time	Adrenal.....	1 time
Spleen.....	2 times	Inf. vena cava.....	2 times
Retroperitoneal hemorr.	2 times	Portal vein.....	1 time
		Iliac vein.....	1 time

TABLE X

Visceral Lesions in 33 Fatal Cases

Small intestine.....	21	Pancreas.....	5
Large intestine.....	20	Lung.....	3
Retroperitoneal injury, hemorrhage....	19	Spleen.....	3
Liver.....	11	Inf. vena cava.....	2
Stomach.....	12	Iliac vessels.....	2
Pleura.....	6	Gallbladder.....	2
Duodenum.....	6	Urinary bladder.....	2
Omentum.....	5	Rectum.....	2
Kidney.....	5	Adrenal.....	1
		Portal vein.....	1

In 38 gunshot deaths following operation, there were autopsy reports on 27 cases. These findings were made available for study through the cooperation of Dr. Charles Norris, the chief medical examiner of New York City. The records showed that in 15 cases, visceral injuries had

been overlooked at the time of operation. This checking of the operation against the postmortem findings will show that the occurrence of overlooked injuries is more common than is usually supposed. Those who have had experience in dealing with cases presenting a multiplicity of visceral injuries will appreciate the many difficulties encountered at operation.

Billings and Walkling,⁶ in their survey reporting 55 gunshot operative deaths with autopsy examination on 49 cases, found nine instances in which visceral injuries of one kind or another had been overlooked at the time of operation.

The average time between receipt of injury and surgical exploration was 3.7 hours. The importance of shortening this time interval has been stressed by

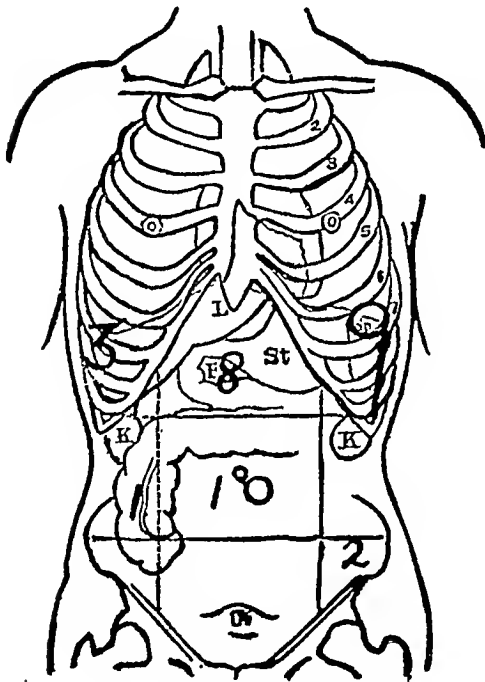


FIG. 9.—Bullet wounds of entrance (fatal cases).

others but we feel that time intelligently spent in the treatment of the patient's initial shock is time well spent and that one may do harm by rushing a patient in shock to exploration.

At the Harlem Hospital, a definite plan of management of these cases has been instituted. Immediately after admission, treatment for shock is instituted; that is, a continuous intravenous drip of 5 per cent glucose in saline, external heat, and morphine. Blood typing is done and in cases with lower abdominal bullet tracts the bladder is catheterized. The blood pressure is followed carefully. Most of the patients are radiographed on their way to the ward or operating room with a minimum of handling.

Abdominal and chest roentgenograms are frequently invaluable in indicating the not infrequent bizarre course of the bullet. The associate surgeon on call is notified immediately. Measures to combat shock are continued and the majority of our serious cases have their intravenous drip started on admission and continued without interruption until their third or fourth postoperative day.

The great importance of blood transfusion, before, during, or after operation, has been frequently stressed by many writers on this subject and is emphasized again here. At the Harlem Hospital in recent years, we have been fortunate in being able to transfuse patients without undue delay. A patient may come to exploration in apparently good condition and suddenly go into collapse and die. Surgeons dealing with this type of case are familiar with this sudden sequence of events and it remains a possibility to be constantly borne in mind and guarded against by the provision of blood donors and their more frequent use.

The choice of anesthesia is an important one. The majority in this series were given open ether. The writer has employed, in selected cases, spinal anesthesia guarded by a continuous intravenous drip and frequent doses of ephedrin with satisfactory results.

Three factors operate in determining the gravity of gunshot wounds: (1) most important, the degree of visceral damage; (2) the severity of the hemorrhage; and (3) the time elapsing between the receipt of injury and surgical intervention. The latter two factors have been touched upon above. The first factor demands more consideration. I do not believe that the importance and gravity of injuries to the retroperitoneal tissues have been sufficiently emphasized. The retroperitoneal tissues may be injured directly, or indirectly by penetration of the duodenum, pancreas, retroperitoneal portions of the large intestine, and rectum.

We see repeatedly cases of injury to a solid viscus or a peritonealized hollow viscus which survive although the lesions may be multiple, but in cases presenting penetration of the duodenum, pancreas, extraperitoneal portions of the large intestine, and the rectum, our prognosis is necessarily guarded because of the accompanying laceration of the retroperitoneal tissues, and their tendency to bleed and undergo suppuration and phlegmonous infiltration.

The technical procedures in our surgical repair should be comprehensive but as simplified as possible. Tamponade of a lacerated bleeding wound of the liver is adequate, whereas suture is tedious and uncertain. Multiple enterorrhaphy is preferable to resection, with proximal enterostomy as an aid when repair has been difficult. Extensive lacerations of the large intestine may be speedily handled by exteriorizing the injured portion. Laceration of the spleen demands splenectomy. Injuries to the duodenum and pancreas should be thoroughly visualized. The duodenum should be mobilized, perforations closed, and the adjacent retroperitoneal space drained. This is most important in pancreatic injuries where wide

TABLE XI
Résumé of Analysis of Fatal Cases

	Liver	Stomach	Small Intest.	Large Intest.	Omentum	Rectum	Bladder	Kidney	Duodenum	Gallbladder	Retroperit.	Pleura	Diaphragm	Lung	Adrenal	Shock	Hem.	Time	Lived		Pancreas	Spleen
† 1.			+	+								+	+			+	+	105	10	G. P.		
† 2.	+	+						+			+		+			+	+	120	3	G. P.		
† 3.	+			+							+		+	+				180	3	G. P.	+	
† 4.				+				+			+		+	+		+	+	120	13	G. P.		
† 5.		+	+	+	+			+				+	+	+		+	+	180	2	Chest		+
† 6.			+	+												+	+	180	2	G. P.		
† 7.			+				+											150	9	G. P.		
† 8.	+	+							+		+					+	+	120	1	Hem.		Vena cava*
† 9.		+						+	+		+					+		60	O. T.		+	
† 10.			+	+												+	+	70	1	Hem.		
† 11.			+	+							Sept. +					+		120	2	G. P.		
† 12.		+									+					+	+	270	O. T.	Hem.	+	
† 13.				+				+			+		+			+	+	180	1	Hem.		+
† 14.	+	+			+							+	+			+	+	120	5	G. P.		
† 15.	+	+	+	+					+							+	+	90	O. T.	Hem.		
† 16.																+		60	2			
† 17.				+							+					0	+	120	5	G. P.		

Note: †=Autopsy cases.
‡*=Overlooked lesions.

drainage is essential. The significance of the posterior perforation accompanying the anterior perforation in a peritonealized hollow viscus is generally appreciated, but in the fixed portions of the large intestine and especially the rectum, it is of great importance. Posterior wounds of the ascending and descending colon demand mobilization of the injured portion, careful closure of the perforation, and wide drainage to the adjacent retroperitoneal space. Injuries to the rectum, in addition to the intra-peritoneal repair, demand excision of the coccyx and exploration of the retrorectal space with closure of the posterior wall perforation and the institution of wide drainage to the retrorectal space.

A large retroperitoneal hematoma had better be left untouched unless it rapidly increases in size. These are grave injuries and exploration is apt to be futile and disastrous.

To facilitate intra-abdominal exploration and repair, we should not hesitate to use long incisions, and to deliberately eviscerate the patient. The eviscerated contents are carefully protected with large, warm, moist packs. I believe that heat applied in this direct manner to the entire splanchnic area, which frequently feels definitely cool to the hand, is of distinct aid in combating shock. In addition, the procedure is of the utmost value in aiding our search for injuries, expediting their repair, minimizing the incidence of overlooked injuries and materially shortening the operating time.

CONCLUSIONS

- (1) Penetrating wounds of the abdomen remain one of the most difficult problems in the surgery of the acute abdomen.
- (2) Penetrating wounds inflicted with the knife are less dangerous than when inflicted with the bullet.
- (3) Blood transfusions are invaluable.
- (4) Attention is called to the importance of adequate exposure—obtained by long incision and evisceration.
- (5) The gravity of retroperitoneal injuries with their demand for wide exposure and extensive drainage is emphasized.

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DISCUSSION.—DR. EUGENE H. POOL (New York) recalled a considerable experience with such accidents in the old Hudson Street Hospital where Doctor Bull did his first suture of a wound of the intestine. There were many Chinese patients as a result of tong warfare. A Chinaman puts a 44 gun under his left arm, marches up to his victim, puts his elbow against the victim's abdomen and pulls the trigger. As a rule the bullet passes through the stomach. A relatively small orifice in the anterior wall of the stomach was usually found, but a vast lacerated wound in the posterior wall. As emphasized by Doctor McGowan, the retroperitoneal structures were variously involved and this was often the important factor. Few survived.

During the War many cases were seen. Débridement was shown to be of primary importance. A recent case brought out a point to which Doctor McGowan did not refer: that is, the possibility of the development of gas-bacillus infection as the result of penetrating wounds, but not resulting from the projectile. If the projectile shatters a bone, bony fragments may become contaminated as the result of passing through the intestine, and lead to gas-bacillus infection. There was one such case in the old New York Hospital. A man was accidentally shot through the sacrum. There were perforations in the large bowel, loops of small intestine, and the bladder. All of these wounds were successfully repaired, but after 36 hours the patient developed a peculiar condition which should have been recognized but was not, and proved to be a gas-bacillus infection of the abdominal wall. Autopsy showed that the peritoneal cavity was clean and that the wounds had been properly repaired, but the bony fragments from the sacrum which had been projected as independent projectiles through the large intestine had been carried into the muscle of the abdominal wall; they had carried microorganisms which were deposited in the devitalized muscle along the tracts of the fragments in which they found a proper medium for their growth. In that case, if proper therapeutic measures had been taken, the patient might have been saved.

DR. JOHN E. JENNINGS (Brooklyn), in searching the records at the Cumberland Hospital in Brooklyn for the past three years, found 30 cases of penetrating wounds of the abdomen. Fourteen of these were gunshot wounds, in which the mortality was practically the same as in Doctor McGowan's series, i.e., 50 per cent. In the stab wounds, the mortality was 33 per cent. A number of the cases (six or seven) of stab wounds of the abdominal wall had been conservatively treated, without opening the abdomen, and all recovered. In looking over the first four volumes of the *ANNALS OF SURGERY* and the ten volumes of the *Annals of Anatomy and Surgery* immediately preceding it, covering the time when the treatment of gunshot wounds of the abdomen by laparotomy was an innovation and a matter to be discussed, and especially in looking over the records of Doctors Bull and Andrews, it was interesting to note that Andrews twice reported four cases in which three recovered without operation. At the same time Doctor Bull began exploring them and reported his success. After making this survey, Doctor Jennings concluded that if the reports of the history of surgery the world over were gathered together and a comparison made of the damage done to the abdomen by gunshot fire with the results of this era, no tremendous advance would be noted. He suggested it would be most interesting if a study of the literature be made, not so much statistically as critically, to find out why the patient died. In a survey of 14 cases of gun-

shot wounds in Cumberland Hospital—seven of whom recovered, seven of whom died—the following facts stood out: In the cases who lived, the operating time was a trifle under one hour; in those who died, something over two hours; inasmuch as the same hands operated in these cases, in all probability the difference in operative time is a fair index of severity of the injury. Cases also did better under general than under spinal anesthesia. Moreover, the degree of manipulation within the abdomen, not only the time spent but the degree with which evisceration occurred, bears a direct relation to mortality. Doctor Andrews—going back to 1888—said he thought it wise to explore the abdomen as soon as necessary to detect, as far as possible, the amount of hemorrhage and as far as possible the amount of leakage and proceed according to what one found at this exploratory operation.

DR. HOWARD LILIENTHAL referred to his experience during the World War and emphasized one point in particular, namely, when a patient has been wounded through the abdomen and there is thoracic injury as well, after the abdomen has been attended to, the chest should be opened by a wide intercostal incision and examination made in that way using a rib spreader. The incision does not take long and is not shocking if done in that way. Before the wound of the diaphragm is repaired, the phrenic nerve as it runs through the pericardium should be found and given a pinch with forceps. This makes the operation much easier and relieves the danger of the reopening of the diaphragmatic wound. When this muscle contracts with respiratory effort the recently sutured wound is liable to reopen.

DR. HERBERT WILLY MEYER referred to a case he presented seven years ago before the Surgical Section of the New York Academy of Medicine. The patient was a young gangster who was shot from behind, receiving two bullet wounds over the sacrum, then at close range he was shot three times more. He was admitted to the Lenox Hill Hospital with five bullet wounds of the soft lead type. One was close to the cervical vertebra, on the first rib. A second bullet was in the soft parts in the axilla. Two other bullets were over the sacral region, and a fifth near the first lumbar vertebra. The fifth bullet had passed through the twelfth rib. It could be felt under the skin, and had entered through the ninth interspace, in the axillary line, passing through the costophrenic space and abdomen and out through the twelfth rib. As we observed him his pulse count went up rapidly with the white cell count. The left side of the abdomen became rigid.

A left rectus incision was made and a large amount of blood encountered in the abdomen. An injury of the spleen was felt. The patient had a very high costal arch. An additional transverse incision was made in an attempt to get up to the spleen which lay high under the diaphragm and was very small. It was impossible to get at the pedicle. There was profuse hemorrhage. An attempt was made to get better access by a chondroplastic resection of the costal arch. A flap was turned up between the rectus muscle and the costal arch. The costal cartilages near the sternum and at the junction with the ribs were divided. With the posterior rectus sheath and the costal cartilages turned up and back, an excellent access to the spleen, diaphragm and stomach was obtained. The spleen was removed. The wound in the diaphragm, now visible, was stitched, a drain put in, and the wound sutured. The patient had a somewhat stormy convalescence, developing an effusion in the chest which was aspirated and did not become infected. He had a *Staphylococcus albus* infection of the wound. Later when the

bullet was removed from the neck a *Staphylococcus albus* infection was also found around it.

Doctor Meyer called attention especially to this procedure as having been published many years ago by Marwedel abroad and presented by his father many times before the New York Surgical Society. In difficult cases—not only of gunshot wounds—under the vault of the diaphragm it provides a rapid and excellent access to the under surface of the diaphragm, the costal cartilage, heals very rapidly and gives a firm wound.

DR. F. W. BANCROFT (New York) called attention to one other type of penetrating wound of the abdomen which, in his opinion, should be treated in a different way. He referred to abdominal birdshot wounds, apt to be encountered in the hunting season. At the Southern Surgical Association meeting last December a paper was read on the subject, wherein it was definitely shown that the best results are obtained by not operating immediately. The shots used for bird shooting are small and when they penetrate the intestine are apt to seal over. Therefore, if no large vessel is injured, the peritoneum protects itself and the patient is likely to recover. These patients are usually in shock and if immediate operation is performed the mortality is fairly high. They should, therefore, be treated first for shock, with careful observation of the blood pressure. If the pressure tends to go down and the pulse up it is a sign that hemorrhage is present and therefore it is advisable to operate. If infection does occur, it will probably form a localized abscess which may be drained at a later time.

Regarding war surgery, he felt that the advance made since the time of the Civil War was not always realized, and cited the interesting case of General Nelson A. Miles, whom he had had as a patient 15 years ago in New York Hospital. General Miles had a scar on his abdomen and when asked where he had received it answered that it was at the battle of Antietam. He was 25 years old at the time, but was already a brigadier general in charge of an army corps.

"I was on my horse," recounted the General, "when I saw a sharpshooter rise up. I turned my horse back, felt a bullet hit me in the region of the abdomen and thought I was paralyzed below the waist. I managed to stick on my horse, however, and got back to brigade headquarters. About that time a shell came along and destroyed all of the brigade headquarters except the area where my orderly and I were. I was kept there for two days, expecting that peritonitis would set in. When this did not occur, I was moved back eight miles over a corduroy road to a field hospital, where I remained five days in the expectation that I would die of peritonitis. As this did not transpire, I was later moved back to Norfolk and, as still my demise did not take place, was transported by ship to Washington. In the hospital there, a consultation was held. The surgeon said, 'Evidently you have not peritonitis at present, or you would not be here; therefore it is safe to probe your wound.' They found that the bullet had been deflected by my gold buckle and had shattered the ilium. They took out several pieces of dead bone but could not find the bullet. Finally, the chief surgeon inserted a long clamp into my thigh, found the bullet, and, placing his foot against the bed, heaved and pulled until he was able to remove it. After he had removed the bullet, I asked him what would be the result. He answered, 'It will be all right unless mortification sets in.' I said, 'What will you do then?' to which he replied, 'We will give you opium enough for the end.'"

REGIONAL (TERMINAL) ILEITIS*

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IN 1932, Crohn, Ginzburg and Oppenheimer¹ segregated from the miscellaneous group of benign granulomas a necrotizing and cicatrizing inflammation confined to the terminal ileum which they believed to be a pathologic and clinical entity, and called it "regional ileitis." Their report is based upon the study of 13 resected specimens. In the fully developed case the 8 to 12 terminal inches of the ileum, ending abruptly at the valve of Bauhin, is thick, boggy and edematous. The serosa is a blotchy red color and the mesentery of the involved segment is thickened and fibrotic and contains numerous hyperplastic nodes. The lesion apparently begins at the valve and gradually tapers off as it ascends the ileum orally. They describe oval mucosal ulcers about one centimeter in diameter occupying the long axis of the mesenteric border which they feel may be the primary lesion. The mucosa is the seat of a diffuse destructive ulcerative process. The remaining coats of the bowel are markedly thickened from inflammatory hyperplasia, giving the involved segment a hose-like structure. The fully developed case shows a marked stenosis of the lumen and, frequently, walled off abscesses and perforations, with resultant fistulae which may extend into the colon. Perforation into the mesentery with the development of a walled off abscess may give rise to pericecal and periappendiceal adhesions and thickening, giving the roentgenologic appearance of hyperplastic tuberculosis. Although focal inflammatory lesions of the serosa resembling tubercles occur, animal inoculations in five of Crohn's cases were negative, and Lowenstein found negative cultures for tuberculosis in three of his cases, in which there was no evidence of pulmonary tuberculosis. Giant cells were present in some cases which they attributed to resultant foreign body reaction around non-absorbable vegetable foreign particles. These authors offer no explanation concerning the etiology or pathogenesis of the disease. Crohn² feels that this clinical entity is not rare since he has seen 28 additional cases in the two years which have elapsed since the original report. Young adults are usually affected.

The clinical features resemble chronic ulcerative colitis; diarrhea (but without tenesmus and usually little blood), lower abdominal pain, fever, continuous loss of weight and anemia. As the lesion begins to obstruct, attacks of abdominal pain (usually in the lower right quadrant), increased peristalsis, and often vomiting, occur. Fistulous tracts may be responsible for local-

* Read before the Joint Meeting of the New York Surgical Society and the Philadelphia Academy of Surgery, February, 1935.

izing symptoms elsewhere in the abdomen. The outstanding physical findings according to the authors are: (1) a mass in the right iliac region; (2) evidences of fistula formation; (3) emaciation and anemia; (4) a scar of a previous appendectomy (half the cases), and (5) evidence of intestinal obstruction.

The roentgenographic findings show obstruction of the terminal ileum without evidence of an intrinsic lesion in the cecum except for a possible fistulous tract. Kantor³ has made a real contribution in his roentgenologic study of six personally observed cases and a review of the material of others. He described (*a*) "the string sign" in the terminal ileum, which is similar to that originally described by Crane as occurring in the colon in mucous colitis; (*b*) filling defects proximal to the cecum; (*c*) an abnormal contour of the last filled loop of ileum, and (*d*) dilatation of ileal loops proximal to the obstruction. He likewise mentions reflex colonic spasm with contractures of the cecocolon but more likely of the cecum proper (teat-like). An actual defect on the mesial aspect of the cecum may be due to adhesions or fistula from the diseased ileum.

CASE REPORT.—A. L., Jewish multipara, 28 years of age, came to the Gastro-Intestinal Clinic of the Graduate Hospital, September 14, 1933, complaining of diarrhea of three months' duration and lower abdominal pain of two months' duration. The past medical history was irrelevant. The pain occurred in irregularly spaced attacks, was gripping and crampy in character, localized largely to the region of the umbilicus and lower right quadrant of the abdomen. It was not related definitely to the ingestion of food but was relieved temporarily by defecation. The diarrhea was intermittent but she often passed from four to seven mushy stools daily, containing mucus. There was no complaint of tenesmus or local rectal discomfort. Vomiting occurred very occasionally. She had lost about ten pounds during the previous year. The original weight before the illness was 160 pounds. A tentative diagnosis of ulcerative colitis, possible minimal tuberculous lesion at the apex of the right lung and incipient ileocecal tuberculosis was entertained. These impressions were not confirmed by laboratory studies. Barium enema and sigmoidoscopic examination showed no evidence which could be interpreted as indicative of organic disease in the colon. The chest film was negative for acid-fast pathology. No ova or parasites could be found in the stools. She was placed on a smooth bland diet and given an antispasmodic sedative mixture.

She was admitted to the hospital August 14, 1934, about 14 months after the first symptoms had appeared. There had been no long remission of symptoms during this interval. The tendency toward diarrhea and vague lower abdominal pain recurred rather frequently. About two months previously the symptoms became aggravated. She began to have attacks of more severe pain around the umbilicus and in the lower right quadrant, associated with increased peristalsis and at times vomiting. The attacks suggested partial bowel obstruction. About the same time an evening rise of temperature as high as 101° F. developed and persisted with some intermissions until admission. Night sweats became a frequent complaint.

Physical examination revealed an emaciated red-headed Jewish female of normal habitus. Her weight was 114 pounds, a loss of 46 pounds since the onset of her illness. The only findings of interest were in the abdomen. It was scaphoid and soft except for muscle guarding and tenderness in the lower right quadrant, overlying a sausage-shaped tender tumor in the region of the cecum which extended over toward the midline about two inches below the umbilicus. The tumor was freely movable. The blood count revealed 5,310,000 erythrocytes, 10.5 Gm. of hemoglobin, 3,300 leukocytes, 68 per cent neutrophils, 29 per cent lymphocytes, two per cent basophils and one per cent

eosinophils. Blood chemistry: sugar 111 mg., urea 10 mg., whole blood chlorides 568 mg. The urine was repeatedly normal and negative for tubercle bacilli. Six sputum specimens and several stools were likewise negative for acid-fast bacilli. The blood serologic examinations and Frei tests were negative. Some stools were negative and others positive for occult blood. No ova or parasites could be found. Sigmoidoscopy showed a normal mucosa. The secretory and motor functions of the stomach were within normal limits as determined by fractional gastric analysis.

Roentgenologic examination revealed a typical string sign in the terminal eight inches of the ileum both after the mouth meal and following a barium enema. Re-



FIG 1.—Roentgenogram showing (1) the string sign of Kantor in the terminal ileum; (2) dilatation of the terminal loop of the ileum proximal to the obstructing lesion; (3) concave shallow subtraction defect on the mesial border of the cecum proximal to the ileocecal valve.

peated examinations failed to show normal filling of this segment. The cecum was not irritable but showed a slightly concave shallow subtraction defect on its mesial border just proximal to the ileocecal valve. A diagnosis of regional ileitis involving the terminal ileum was based upon: (1) a long history of intermittent attacks of pain in the lower right abdominal quadrant with mucous diarrhea but without tenesmus; (2) tenderness and muscle guarding in the lower right quadrant associated with a movable, palpable mass corresponding to the position of the terminal ileum; (3) a persistent string sign in the terminal ileum in the roentgenographic film; (4) absence of any clinical or roentgen

ray evidence of tuberculosis and the absence of signs of tuberculosis or any other type of intrinsic lesion in the cecum.

First Operation.—September 24, 1934. Laparotomy was performed by one of us through a low right rectus incision. It was found that the terminal ileum and ileocecal valve were fixed and could not be delivered. About 16 to 17 centimeters of the terminal ileum were covered by a fibrostenotic exudate and the normal glistening sheen of the wall was absent. The walls were greatly thickened and rigid, feeling very similar to a garden hose. Proximal to this region for a distance of seven centimeters there was a more acute reaction in the serosa, the vessels being engorged and the fibrostenotic exudate merging gradually into a plastic exudate. Still farther on, beginning at a distance of 24 centimeters from the ileocecal junction, the diseased segment quite abruptly merged into normal appearing bowel. The mesentery of the distal 24 centimeters of the ileum was thickened and boggy and there were several enlarged lymph nodes in the base of the mesentery near the ileocecal junction.

The presenting surface of the cecum and ascending colon did not appear or feel to be involved, but at the appendiceal region the cecum was tightly fused to the ileum by a well organized fibrotic membrane. The appendix was not visible nor could it be palpated in spite of a careful search. There was no evidence of fistula formation. While



FIG. 2.—Resected specimen consisting of terminal ileum, appendix, cecum and one-half of the ascending colon.

manipulating the cecum about two to three cubic centimeters of cream-colored pus escaped from the base of the mesentery where it was adherent to the cecum, a culture of which was reported as overgrown with *B. proteus*. Because of the free pus it was deemed unwise to do a short-circuiting anastomosis and resection in one stage. Consequently a side-to-side anastomosis was performed between the ileum, 50 centimeters proximal to the ileocecal valve, and the midportion of the transverse colon. The abdomen was closed without drainage. The convalescence was uneventful.

Second Operation.—After an interval of 16 days the second stage was performed. There was no important change in the gross pathology noted other than the presence of a few fine fibrinous adhesions at the site of our previous operation. At this stage the ileum was transected about eight centimeters distal to the anastomosis and the open ends were inverted. The ascending colon, which was unusually short, was transected

about at its midpoint and the open ends also inverted. The ileum, cecum and ascending colon between these transected areas were resected *in toto*. The abdomen was closed without drainage.

Following this the patient had an uneventful convalescence and was discharged from the hospital, November 11, 1934, one month after her second operation. At this time her weight was 104 pounds, ten pounds less than the weight on admission. The erythrocyte count was 5,210,000, and the hemoglobin 67 per cent (11.5 Gm.) She was having three to four bowel movements daily, normal in color and semiformal. She felt quite strong, vigorous and happy. When last seen on January 16, 1935, she had gained 34 pounds, having two to three bowel movements daily, was carrying on her housework in a normal fashion and had no complaints and no restrictions in her diet. A follow up roentgen ray examination with a barium enema showed that the ileocolostomy was functioning properly.



FIG. 3.—Showing the lumen of the terminal ileum, ileocecal valve, cecum and ascending colon opened. Gradual thickening of the wall of the terminal ileum toward the ileocecal valve where the lumen is almost completely obstructed.

Pathology.—The gross external pathology was as described above. Dr. Case found the appendix even on close examination remained concealed. It was entirely covered by a thick, well-organized fibrotic membrane which bound the ileum and the cecum together. The appendix under this membrane was doubled back on itself like a hairpin, and the terminal two centimeters were twisted into a corkscrew spiral. The bent portion of the appendix at its midpoint was fused tightly to the wall of the ileum about four and a half centimeters from the ileocecal valve on the mesenteric border. At this point an ulcer had completely perforated the wall of the ileum and fistula formation was prevented by the appendix becoming adherent here.

Upon opening the terminal ileum it was found that the walls reached a maximal thickness of six Mm. just oral to Bauhin's valve and tapered off as they progressed proximally until at a distance of 24 centimeters they were of normal thickness and consistency. The lumen in the distal 17 centimeters would barely admit a No. 10 French catheter. The ileocecal valve itself formed a dense fibrous ring with a three Mm.

opening in the center. The mucosa for a distance of six centimeters proximal to the valve was almost entirely replaced by dense, white, contracted cicatricial tissue, there being only a few small irregularly placed islands of mucosa present. An old scarred perforating ulcer about two centimeters in diameter was present as mentioned above, four and a half centimeters distal to the ileocecal valve on the mesenteric border. At a distance of 19 centimeters from the valve near the mesenteric groove was a small shallow ulcer one half centimeter in diameter, while just proximal to this was a larger oval ulcer measuring two and a half centimeters in its long axis, which was in the direction of the fecal flow. The mucosa elsewhere was edematous and bulbous in appearance.

The cecum and ascending colon were not involved in the pathologic process that ended abruptly at the oral side of Bauhin's valve. There were no ulcers in the mucosa of the appendix but its walls were thickened and fibrotic.

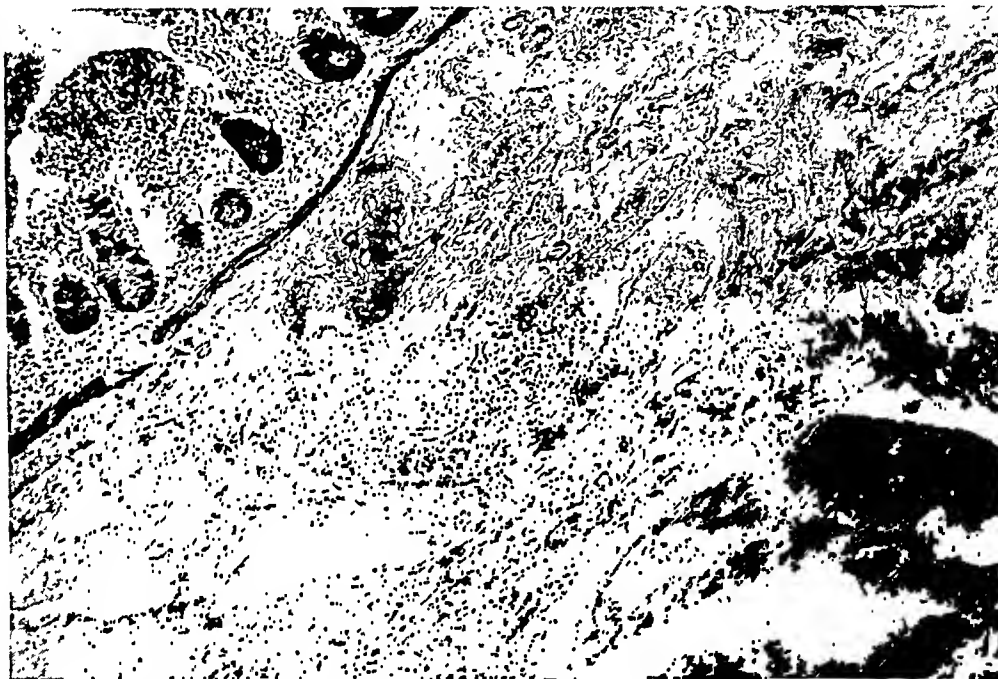


FIG. 4.—Section of the mucosa, submucosa and a portion of the muscularis. Showing a non-specific inflammatory reaction.

Microscopic Pathology.—Histologic sections revealed a non-specific, infectious, granulomatous process throughout. The chronicity of the process varied from old to recent as it progressed from the distal to the proximal regions of the lesion, respectively.

A section through an ulcer 17 centimeters from the ileocecal valve showed a complete destruction of the mucosa in the central aspect. The base was covered with fibrin infiltrated with polymorphonuclear leukocytes and the edges were undermined. The submucosa was slightly encroached upon by the ulcer, but that which remained was a dense mass of connective tissue infiltrated with leukocytes, polymorphonuclear cells being predominant. There was a slight hypertrophy of the muscular layers with evidence of the inflammatory process extending along the septums. The serosa was thickened and presented a picture very similar to that of the submucosa except that edema was a prominent feature here in addition to the inflammatory reaction.

Sections distal to the one described above varied only in the thickness of the wall of the ileum and that the polymorphonuclear leukocytes relinquished their predominance in favor of round cells and plasma cells. The walls became progressively thicker almost by mathematical precision from the proximal to the distal aspect of the lesion. There were no foreign body giant cells or tubercle-like lesions in any of the sections.

One of the neighboring lymph nodes was sectioned. Its architecture was fairly well preserved, but there was a hyperplasia of the reticulo-endothelial cells. The germinal centers likewise shared in the hyperplasia with compression and narrowing of the surrounding rim of lymphocytes. The sinuses, both central and peripheral, were widely dilated and filled with endothelial cells. There were no giant cells or tubercles present here either.

The appendix revealed a marked thickening and fibrosis of the submucosa layer infiltrated largely with lymphoid and plasma cells. The muscular layers were atrophied. The subserosa was also fibrosed and showed collections of lymphoid cells perivascular in distribution. Continuous with the serosa was an organized membrane of dense connective tissue. During the process of sectioning and fixing the mucosa was destroyed and thus was not examined microscopically. However, on gross examination when the appendix was opened there was no interruption in the continuity of the mucous layer.

This case corresponds to the description of regional ileitis given by Crohn. All of the cardinal clinical features were present: youth, weight loss, fever, diarrhea without tenesmus, pain in the region of the umbilicus and right iliac fossa with vomiting, history of 14 months' duration of a palpable mass in the lower right quadrant with tenderness, and the absence of roentgen or sigmoidoscopic evidence of intrinsic disease in the colon. The cardinal roentgen finding, described by Kantor, the string sign, was well demonstrated and the evidence of intrinsic involvement of the mesial aspect of the cecum was likewise present. Grossly, this resected specimen corresponded exactly to the original description of regional ileitis. A perforation in the mesentery of the ileum had occurred and except for a barrier of the appendix, undoubtedly would have caused a fistula into the cecum. The disease process was most advanced at the ileocecal valve and just proximal to it.

Crohn, Ginsburg and Oppenheimer¹ are to be commended for the first clear-cut description of a clinical entity which in the past has probably been mistaken for tuberculosis or inoperable malignancy. Their paper is of particular importance at this time because it has stimulated interest in one of the most puzzling and difficult fields of abdominal disease, the diagnosis of small intestinal lesions. It now seems certain that the terminal ileum is occasionally the site of a progressive type of benign inflammatory lesion in which no proof of tuberculosis can be found. Speculation will continue concerning its etiology until a specific agent is found in the lesion or until a considerable number of early inflammatory lesions of the terminal ileum have been observed to terminate in what we now understand as terminal ileitis. It is not unreasonable to postulate that any primary inflammatory mucosal disease in the terminal ileum might in the end resemble the entity under discussion. There are many who feel that chronic ulcerative colitis may be originally initiated by a number of different primary agents. Certainly both amebic colitis and bacillary dysentery may eventually cause the same terminal pathologic lesion as the ordinary chronic type of ulcerative colitis of unknown etiology, possibly due to the inroads of secondary invading organisms. Hence it is conceivable that chronic ileitis may result from a number of heterogeneous primary irritating factors.

In the absence of a known etiologic agent, one should consider other reasons for the predilection of this type of lesion for the terminal ileum. It is possible that some peculiarity of the anatomy of the terminal ileum, its mesentery or its blood supply may predispose toward the development of a chronic granulomatous inflammation in this region. An arrangement which would permit of twisting, angulation, and partial intermittent intussusception or volvulus has been considered. Ginzburg and Oppenheimer,⁸ in discussing the etiology of non-specific granulomas of the intestines, mention the possible rôle played by a disturbance in the vascular mechanism. They referred particularly to repeated and self-reducing intussusception or recurrent partial volvulus at the ileocecal valve, and emphasize the inability of differentiating, in the end stages, granulomatous lesions due to primary vascular insufficiency from those due to primary infectious agents. The abrupt cessation of the inflammatory process at the ileocecal valve could be explained on the basis of recurring self-reducing intussusception. The youth of most of these patients, and the lack of evidence of a specific etiologic agent, and the frequency of the involvement of the terminal ileum as well as the occasional involvement of other portions of the ileum suggested this possibility.

Cases reported to date give no idea of the anatomic configuration of the colon or the habitus of the owner of the disease. Is the disease more prone to occur in patients with a high cecum and a tendency to ileal stasis or in those with long pendulous ceca and low loose mesenteries, or does it occur without relation to these anatomic variations? According to Batson, the ascending branch of the ileocolic artery, which supplies the cecum, is more or less fixed in most anatomic specimens, whereas the terminal branch of the same artery, which supplies the terminal ileal segment, is capable of considerable rotation. It is conceivable that an unusual mobility of the terminal ileal segment might by pinching or twisting the terminal branch of this artery tend to devitalize the part in much the same way as an intussusception.

Since the disease seems to be most advanced at the valve, some primary neuromuscular abnormality here might act as a predisposing factor, inducing ileal stasis, infection, infiltration and finally obstruction.

Another possibility is primary appendiceal disease. This must be considered because of the youth of the reported patients and the history of previous appendectomy in many of them. It would not be possible in our case, for example, to exclude the possibility of a primary appendicitis with adhesion to and secondary involvement of the mesentery itself or of nodes in the substance of the mesentery. It is conceivable that a lymphangitis and surrounding inflammation might encroach upon or infect the blood supply and in this way slowly devitalize this segment of ileum, producing a lesion like that of terminal ileitis. In this classic case of ours, the appendix formed the wall of an abscess in the mesentery. The appendiceal inflammation was probably secondary, but we do not see how one can be sure of this. The

original description of the disease dismisses the appendix as a primary focus on the basis that the disease never transcends the valve of Bauhin. We feel that there is insufficient evidence so far to justify one in excluding primary appendiceal disease with secondary involvement of the mesentery and finally of the terminal ileum, in some cases.

The differential diagnosis in our case entailed primarily ruling out hyperplastic tuberculosis. The absence of lung tuberculosis and of intrinsic cecal disease tended to exclude this possibility. We are, however, very definitely of the opinion that tuberculosis should not be excluded in any case until after a microscopic examination. There is apparently no known pathologic analogy in man or the lower animals for considering this entity tuberculosis in the absence of the commonly accepted bacteriologic and tissue reactions with which all well-trained pathologists are familiar.

It is possible that the pathologic lesion under discussion may follow an acute terminal ileitis, an inflammatory reaction quite like acute typhilitis. This seems borne out by cases of the type described by De Courcy,⁴—an acute illness in a girl 20 years of age, resembling acute appendicitis following a cold in which the lower 12 inches of ileum were acutely inflamed with a plastic exudate. Clute⁵ mentioned a case of this general type and Crohn discusses similar cases. It will be impossible to determine the importance of this factor until known acute inflammatory lesions of the terminal ileum have been followed over a period of years and many more sections of bowels in various stages of inflammation are resected and examined.

We feel that an analysis of the cases so far reported justifies the acceptance of the term regional (terminal) ileitis as a pathologic and clinical entity, in the same sense that chronic ulcerative colitis is used to describe a clinical and pathologic entity, recognizing the possibility of its protean etiology. Naturally, some lesions of this type will occur in combination with similar involvement elsewhere (Brown, Barger and Weber⁷) (Homans and Haas⁶) in the bowel. Pathologic processes of this general nature have been reported in other parts of the small and large bowel. These reports in no sense detract from the clinical importance of the lesion under consideration. Rather they serve to emphasize that chronic stenosing granulomata, just as ulcerative tuberculosis, may occur anywhere in the intestinal tract, but for some reason or reasons show a marked predilection for the terminal ileum.

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RADIUM BURNS OF THE RECTUM

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SEVERE radium burns of the rectum are usually, if not always, the result of the local application or interstitial use of radium as contrasted to the effects obtained by radium packs where the element is applied at a distance from the rectum either over the sacrum or on the abdomen. Where patients with third-degree radium burns of the rectum have come under our care their burns have been either the result of treatment of carcinoma of the rectum, hypertrophy of the prostate or leukoplakia of the rectum by the introduction of radium into the rectum.

The effect of radiation on both normal and neoplastic tissues has been described by many workers in that field, and though the histologic and gross evidence of tissue changes are fairly well known, "the actual intricate mechanism by which radiation produces injury to cells is vague, and its elucidation must await prolonged biophysical analysis."¹ It is generally recognized that radiation injures the nuclei of tissue and tumor cells, causing degenerative changes in them, and also may injure the cytoplasm of the cell. The blood vessels in the irradiated area are particularly effected, hyperemia developing, followed by marked degenerative changes in the vessels, thickening of their walls and extensive thrombosis. The connective tissue is markedly stimulated in its growth and a lymphatic infiltration occurs. These are but the high lights of the reaction of tissue to radiation.

Two gross types of reaction to radium radiation are seen in the rectum; namely, hyperemia and actual necrosis or ulcer formation. Hyperemia of the rectal mucosa is practically always observed after any considerable radiation of the rectum and may be very acute, if radium, without proper screening, has been inserted into the rectum for treatment of a local lesion. It usually develops ten days to two weeks after the use of the element and increases in intensity up to three to six weeks, when it slowly recedes. The patient with such a reaction develops smarting and burning in the rectum, associated with tenesmus, which may be constant and requires morphine to control. An excess of mucus is formed which may be passed in small amounts, and if straining is severe, it may be blood stained. The rectal mucosa is plum colored, often covered with petechial hemorrhages and is extremely sensitive to touch. Such a severe reaction may cause the patient symptoms for six to eight weeks. Milder or very transitory states of hyperemia with correspondingly milder symptoms also occur.

It is, however, upon the ulceration or third degree burns following radiation that particular emphasis should be placed. These lesions may be diffuse, if proper screening of the radium was omitted, or local, in which event a

RADIUM BURNS OF THE RECTUM

persistent indolent ulcer replaces the neoplastic ulcer that was radiated. As the hyperemia around the ulcer recedes, it has a rather characteristic appearance, being definitely outlined, rather shallow, and is covered with an exudate of fibrin and cellular débris that gives it the appearance of a white pellicle or membrane. Due to connective tissue contraction, radiating lines of constriction are seen in the mucous membrane surrounding the ulcer and the mucosa appears smooth and atrophic, without its usual delicate folds. In four of our patients the ulcer was over the prostate at the former site of the carcinoma, and was firmly adherent to the prostate and immobile. In one patient a small lesion the size of a dime had replaced the site of an adenoma destruens. In two patients the ulceration was diffuse, as a result of treatment of hypertrophy of the prostate and leukoplakia respectively.

Histologically, the picture was typical of ulcers following radiation in any part of the body. A dense, unorganized necrotic base, under which marked fibrous and leukocytic infiltration was present. Damaged nuclei in the cells were in evidence. The walls of the blood vessels were thickened. Practically no evidence of healing was in evidence except perhaps the contraction of the ulcer by fibrosis. For purposes of discussion eight cases with marked radium burns of the rectum are selected.

In six of them the burns resulted from treatment of carcinoma of the rectum and in two from treatment of hypertrophy of the prostate and leukoplakia of the rectum respectively by the local application of radium.

Of the six radium burns occurring following treatment of carcinoma there was suspicious gross evidence of carcinoma in two (Figs. 1 and 3). In the center of these ulcers there were some irregular nodules much firmer and less friable than usually felt in adenocarcinoma of the rectum, but nevertheless highly suspicious. In the other four patients the lesion was a flat ulcer with marked scar tissue contraction about it and had no characteristics of a carcinomatous ulcer. When these six radium burn ulcers were examined histologically, three had very definite evidence of carcinoma in the depth of the ulcer under the necrotic exudate (Figs. 2 and 4), and in two degenerated cells were found in the base of the ulcer which were histologically very suggestive of carcinoma, though that evidence must be somewhat less definite than usual due to the badly damaged condition of the nuclei of all the cells in that region (Fig. 5). In the sixth patient, aged 79, where an adenoma destruens had been removed and radium needles planted into the rectum at its base, the burn resulting was not in any way typical of carcinoma and repeated biopsies over a period of five years showed no tumor cells. This patient died of pneumonia and no postmortem was obtained.

In the five patients having radical removal of the rectum a careful dissection of the specimens for involved lymph nodes showed positive findings in one instance. This patient was a young man 30 years of age in whom early extension into the lymphatics would usually be expected. As the remaining cases were from 30 to 62 years of age and had had symptoms of carcinoma before the radium treatment for from four to six months (with one excep-

tion), it is not worthy of particular comment that only one had glandular involvement, as the average patient has only 35 per cent of a chance of having such involvement when operated upon.

Pathologically considered, it seems reasonable to say that in these six patients with radium burns following the treatment of carcinoma of the rectum by radiation, three showed definite evidence of carcinoma, two probable evidence and one, no evidence of tumor cells in the burned area.

Clinically speaking, Case VI, with the small burn following radiation of the adenoma destruens, was only moderately uncomfortable, having a slight bloody discharge and some slight pain but in general was in good health. The remaining seven patients, including one with an extensive burn following radiation of an hypertrophied prostate, were practically incapacitated. Marked tenesmus, frequent evacuations of blood, mucus, bladder irritability, sleeplessness, loss of appetite and anemia were present in varying degrees.

From a surgical standpoint the radical removal of the rectum was made very difficult because of loss of the normal cleavage planes by reason of extensive fibrosis and also because of dense adherence of the radium burn to the prostate in three patients, in whom it was necessary to remove the posterior one-third to one-fifth of the prostate by knife excision to entirely remove the necrotic area of the burn. In these patients the prostate looked edematous and fibrotic, as if it had also been markedly affected by the radiation. Following operation a white exudate formed over the prostatic bed which persisted for weeks but finally cleared up. Persistent oozing at the operation necessitated transfusion of blood in nearly all of the cases. The postoperative course was stormy in all, as pain, slow healing of the wounds and profuse wound discharge complicated the convalescence. In the patient with extensive burn following treatment of prostatic hypertrophy, the rectum was split open posteriorly after removal of the coccyx and the burn was thoroughly excised and the adjacent mucosa mobilized to cover the defect as much as possible. All of the patients recovered from the operation. One has since died of carcinoma, having local as well as general recurrences. The remaining six are well and free from recurrence, one to two and one-half years following the operation.

In conclusion, it seems evident from this small series of cases that when carcinoma of the rectum is treated by radium and a burn results, that carcinoma may still be present in the base of the burn or in the lymphatic nodes and that radical removal of the rectum is indicated. If radium burn in the rectum results from treatment of other lesions, local removal of the burn is the treatment of choice as applies in radiation burns elsewhere in the body.

CASE REPORTS

CASE I.—I. K., male, aged 56. Diagnosis of carcinoma of rectum five months ago. Ulcer over prostate, treated by insertion of radium into the rectum at two sittings, 2,800 mg. hours administered. Following treatment symptoms improved but now he has bleeding and tenesmus and has lost weight. Examination May 12, 1932, shows scar tissue contraction at level of prostate with some induration and superficial ulceration.

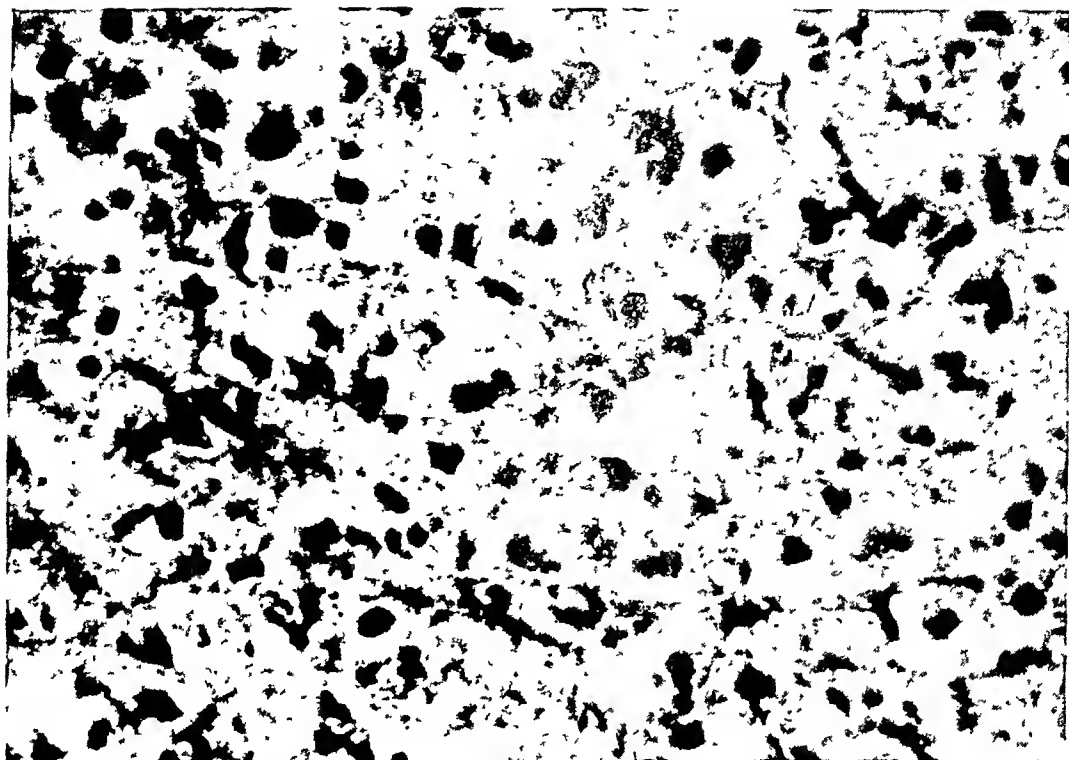


Fig. 1.—(Case II).—High power photomicrograph of tissue in depth of radium burn of rectum where tumor has grossly been destroyed. Questionable tumor cells.



Fig. 2.—(Case III).—Gross specimen of resected rectum showing radium burn with tumor tissue in it two years after local application of radium, dosage unknown. See Fig. 3 for histology.

Operation May 21, 1932, exploratory laparotomy and colostomy. May 4, 1932, posterior resection of rectum. Four inches of bowel removed intraperitoneally. Much oozing. Transfusion of 500 cc. blood. Specimen shows ulcer two and one-half inches by one inch on anterior wall. Adherent to prostatic tissue. Sections show degenerated cells resembling carcinoma in base of burn. Lymph nodes negative. Stormy convalescence. Prostatic area has all appearance of radium burn but eventually healed. Patient now well and at work.

CASE II.—C. F. M., male, aged 50. Symptoms of blood and increase in number of stools for three months. Examination February 15, 1932, shows carcinoma size of dollar on posterior wall of rectum with crater in center above mucocutaneous line. Lesion is freely movable but involves muscularis.

Radium treatments were administered elsewhere in this case in March, 1932. The first consisted of 48 mos. filtered with 1 Mm. brass and $\frac{1}{2}$ Mm. silver placed high up in the rectum against the growth for eight and one-half hours. Two days later, three tubes of radon

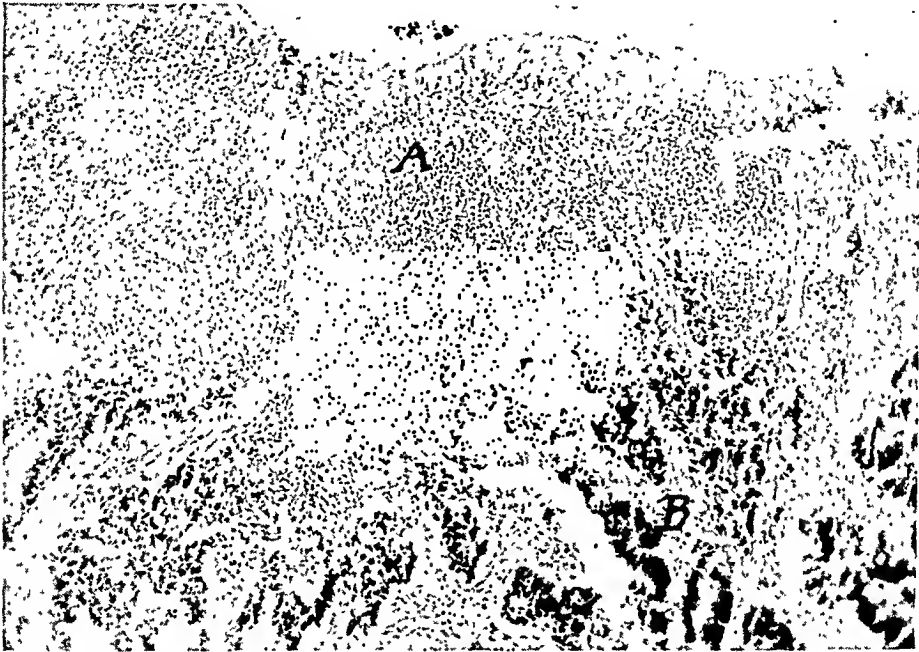


FIG. 3.—(Case III).—Photomicrograph showing necrosis of radium burn (A) and tumor cells in the depth of the burn (B).

totalling 129 mos. were placed for four hours against the lesion, held in place with gauze packing. Two days later a similar application was placed lower down on the lesion, and two days later a similar treatment was given. The total of these four treatments between March 8 and March 14 was 1,973 mo. hrs. On March 17, 17 mg. platinum needles were placed throughout the rectal growth one cm. apart, and left in place for 48 hours. A very severe reaction followed, including a pulmonary embolism. Ever since has had tenesmus, 6 to 50 bowel movements daily.

On June 21, 1932, was bedridden, taking morphine, in continuous pain and was pale and emaciated. Digital examination of rectum shows no tumor, marked scar tissue formation and superficial ulceration at its former site. June 23, exploratory laparotomy and colostomy. Liver and lymph nodes negative. July 22 blood transfusion 500 cc. Posterior excision of rectum. Eight inches of bowel removed. Prostatic bed edematous. Marked fibrosis in region of middle hemorrhoidal vessels. Ulcer from radiation two and one-half by two inches on lateral wall of bowel. No gross evidence of carcinoma. Microscopically, very probable carcinoma cells in depth of ulcer (Fig. 1). No involvement of lymph nodes found. Patient made a slow convalescence. At present, the patient is well except for a phlebitis. No evidence of recurrence.

RADIUM BURNS OF THE RECTUM

CASE III.—S. W., male, aged 62. In June, 1931, carcinoma of rectum diagnosed elsewhere and treated by radium. Dose unknown but given by application in rectum. In good health until present, November 20, 1933, when blood in bowel movements recurred. Examination shows flat ulcer about two and one-half inches in diameter at level of prostate and adherent to it. Dense scar tissue about it. Operation November 29, 1933. One stage abdominoperineal resection followed by blood transfusion. Posterior one-fifth of prostate was removed with the adherent ulcer. Flat ulcer in rectum with definite carcinoma in center of it (Fig. 2). Microscopically cancer (Fig. 3). Lymph nodes negative. Patient made excellent recovery and is now in good health.



FIG. 4.—(Case IV).—Gross appearance of radium burn of rectum following use of 146,000 Mg. hours by radium packs and 3,000 Mg. hours by rectal applicator. Note questionable tumor nodules and flattening of normal mucosal rugae. For histological picture see Fig. 5.

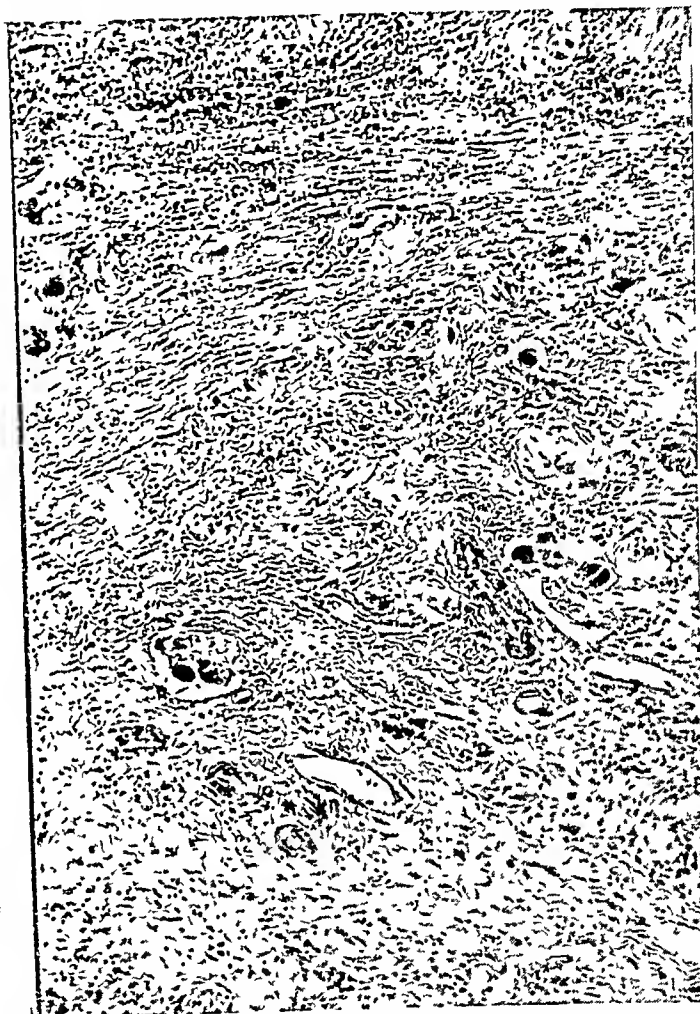


FIG. 5.—(Case IV).—Photomicrograph showing tumor cells in depth of burn.

CASE IV.—J. J. S., male, aged 61. Five months ago frequent bowel movements containing old blood. Lost 30 pounds in weight. Examination May 19, 1933, shows a movable carcinoma two and one-half inches in diameter just above the mucocutaneous line on the left side, reaching from prostatic region to hollow of sacrum. Biopsy showed carcinoma. Patient was treated elsewhere with radium. 146,000 mg. hours with the four gram radium pack, 10 cm. distance, 10 cm. portal, 1 Mm. platinum filtration was administered in two series: July 11 to 28, 1933 and October 3 to 13, 1933. In addition to the external radiation he also received radiation by means of a rectal applicator as follows: 30 mg. for 100 hrs., 1 Mm. platinum, total dose 3,000 mg. hours.

Patient returned November 16, 1933, suffering severe pain. Had lost more weight. Examination shows marked scar tissue contraction but very little, if any, evidence of tumor. Large ulcer adherent to prostate and immovable. Two blood transfusions were given and the rectum removed abdominoperineally in one stage (Figs. 4 and 5). It was necessary to remove the posterior one-fourth of the prostate with the adherent ulcer. Stormy convalescence with eventual recovery and subsequent return to work.

CASE V.—F. D., male, aged 31. In February, 1932, polyp removed from rectum elsewhere which was subsequently diagnosed carcinoma. An experienced radiologist treated the area with 100 mg. of radium contained in two 50-mg. tubes in tandem, applied for a period of 15 hours. Screened by five Mm. of platinum, one Mm. of lead and one Mm. of aluminum. The distance from the radium to the mucosa was a minimum of 2.5 Mm. Following this, patient had a severe local reaction and eventual ulceration, followed by stricture, great difficulty in having bowel movements which contain blood and pus. May 7, 1932, there was an ulcerating lesion on the posterior wall of the rectum involving the sphincters and a stricture at the level of the levator muscle. A deep biopsy of the ulcer was made but no carcinoma was found. A colostomy was done, hoping to give the patient relief from severe pain. June 8, 1932, severe pain continuing it was decided to excise the radium burn. While so doing a nodule in the base of the burn was seen which proved to be carcinoma. A radical excision of the rectum was then carried out from below, opening the peritoneum and removing about eight inches of the rectum. Other carcinomatous nodules were found along the superior hemorrhoidal vessels. Examination of the base of the radium burn showed carcinoma. The patient made a good recovery and returned to work, but on November 24, 1933, returned with sciatica and eventually developed lung metastases, as well as a local recurrence, and died September, 1934.

CASE VI.—L. G. Y., male, aged 76. April 11, 1924, blood in stool. Above prostate on anterior wall is a pedunculated movable polyp with indurated base. Feels like adenoma destruens. April 22, 1924, removed by cautery, after splitting rectum open posteriorly. Four needles containing ten mg. each implanted into previous site of tumor and left five hours. November 28, 1924, slight ulceration at previous site of tumor, white and covered with a pellicle. Biopsy shows necrotic tissue but no carcinoma. November 26, 1926, same picture and again biopsy negative. July, 1927, picture the same, patient having no symptoms. In 1929, died of pneumonia. This lesion was apparently cured by local removal followed by radium.

CASE VII.—N., male, 63. Symptoms of large prostate treated elsewhere by having radium inserted into rectum two months ago. Now having severe tenesmus. Passage of bloody mucus, is sleepless and losing weight. Examination shows area three inches in diameter on anterior wall of rectum, ulcerated and covered with a white exudate. The surrounding mucosa is deeply injected and bleeds easily. No suspicion of carcinoma. The rectum was split open posteriorly, the area of ulceration excised, the mucosa adjacent to it mobilized and the defect partially covered by it. The rectum was sutured in layers. Immediate relief from pain and favorable convalescence. Histologically the tissue showed a radiation burn with no evidence of carcinoma.

CASE VIII.—F. M., male, aged 30, has marked leukoplakia of the rectum, with thick parchment-like rough mucosa, extending upward for about two inches above the mucocutaneous line. This was excised and promptly recurred. Following recurrence patient went elsewhere and had radium introduced into the rectum. A few weeks later he developed severe pain and on returning for examination was found to have a disappearance of the leukoplakia, but a radium burn involving an area about one and one-half inches long by three-quarters of an inch wide. This was excised and the normal mucosa pulled down over the area. The amount of radium used in this case was not known. Following this operation the patient made a good recovery.

REFERENCE

¹ Stewart: Arch. Surg., vol. 27, p. 97-A, 1933.

THERMAL BURNS

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THERE has been in the past decade such a wealth of literature, both clinical and experimental, on the subject of burns that it is difficult to find a reasonable excuse to increase it. Yet as the interested physician reads the various clinical opinions and studies experimental results by competent observers, he is immediately conscious of a lack of harmony in not only the theoretical and experimental results, but also in the methods of treatment. He is also conscious of improved mortality statistics but the improvement seems disproportionately small when compared with the advancement in knowledge claimed. He is confronted with experimental data purporting to show that the fatal effects of burns are due variously to a reflex phenomenon, increased capillary permeability, a tissue toxin or a bacterial toxin. He is amazed that the proof in each case seems conclusive. The statistical studies from the various clinics all show improvement but in each instance there are essential differences in methods of treatment and each clinic is convinced that its procedure is correct.

In this paper an attempt will be made to harmonize both clinical and research data and to outline a method of treatment based upon the conception that the phenomena induced by thermal burns are in reality a sequence of events and should be treated as such. This seemingly impossible task simplifies itself immediately when one separates from the mass of clinical and experimental evidence certain basic facts, all of which have been reasonably proven. First, the phenomena induced by burns are not only local but also general in action. Secondly, there are definitely reflex, biochemical and toxic phenomena. An effort will be made to show that each of these facts is probably true, to place them in their proper order, and to evolve a sequence of therapy which will not only actively combat but will anticipate and prevent their ill effects. This effort to harmonize is the only claim to originality that the author makes.

There is certainly nothing new or revolutionary in the idea that the cause of death in severe burns is due to general and not local phenomena. That the general factor is precipitated by the local lesion is obvious. As early as 1868 Wertheim¹ advocated the idea of a toxin circulating in the blood as the prime factor in burn mortality. That he was not alone in his attitude is illustrated by Pontick² advocating the same idea in 1876. A number of rather unique theories were put forth at this time to explain the phenomena.

The theory that the burn decreased the respiratory function of the skin to the point where life was impossible is as unique as it is untenable in the light of present-day physiology. The theory that the toxicity was due to the retention of products normally excreted by the skin was disproved by Kijanitzin³ in 1893 when he demonstrated that the ill effects of the gilding experiments were due to abnormal biologic conditions produced in the skin and that the gilding destroyed the vitality of the skin involved, producing a microscopic picture not unlike that seen in a first-degree burn. Welti⁴ in 1889 disproved the theory of death being due to failure of the heat-regulating mechanism by protecting the burned animal from such heat dissipation and showing that there was no reduction in mortality. Markusfeld and Steinhau⁵, in a series of brilliant experiments, demonstrated that the interference with the nerve supply of the burned animal had no effect upon the ultimate result, while division of the blood supply to the burned area prevented the constitutional reaction.

That the first ill effect of a severe burn may be a reflex shock phenomenon, due to pain and fright, has been adequately proven by Underhill, Kapsinow and Fisk.^{6, 7, 8, 9, 10} These investigators noted that in animals burned under anesthesia the primary shock seen in the clinical case did not occur. Furthermore, Underhill and his colleagues showed that the primary shock occurred too quickly for it to be caused by an actual reduction of the total blood volume, and that the loss of the power of absorption from the burned area in the first 12 to 24 hours following a burn precludes the explanation of a protein absorption product. That the primary shock could be due to a bacterial toxin is untenable in the light of our knowledge of bacteria and their toxins and the lack of absorptive power in the burned area in this early stage likewise precludes this possibility. From the above data one can therefore state with reasonable certainty that in severe burns there may be a primary shock due to pain and fright.

The primary shock, however, is a transitory phenomenon to which the patient either succumbs, or responds to treatment within a relatively short interval. It may be followed by a secondary stage which, in its clinical symptomatology, could be likewise called shock. This for the sake of clarity we will call secondary shock or the second stage of burns. It is concerning the etiology of the secondary shock that most of the controversy rages. It was generally accepted up to the last few years that the ill effects of burns during this stage were due to toxins liberated in the burned area by protein disintegration which were absorbed into the circulation. The leading proponent of this theory was Davidson¹¹ who in 1925 summarized the evidence in favor of this hypothetical toxin and presented the tannic acid treatment of burns. Although Mitchiner¹² claims the Chinese used this treatment five thousand years ago when it was their custom to treat burns with tea leaves, it does not detract from the credit which is due Davidson for instituting the first major advance in the modern treatment of severe burns.

To uphold the tissue toxin theory we have the work of Reiss¹³ in 1904

who reported a toxin in the urine of the burned case which was toxic upon being injected into the laboratory animal. Pfeiffer¹⁴ in 1905 reported the isolation of cleavage products from the burned skin which were neurotoxic and necrotoxic. Others too numerous to mention conducted investigations to show the presence of this toxin. It remained, however, for Robertson and Boyd¹⁵ in 1923 to present the strongest evidence for this theory. Briefly summarized these investigators grafted burned skin onto normal animals who showed toxic manifestations in about eight hours. They injected blood from burned animals into normal animals and found the whole blood to be highly toxic whereas blood serum alone was nontoxic. The injection of alcoholic extracts of normal skin were found to be nontoxic to normal animals while the injection of alcoholic extracts of burned skin were immediately followed by toxic symptoms. These investigators isolated and analyzed this toxic and found it to be of two parts. The first was thermostabile, diffusible and neurotoxic, and the second, thermolabile, colloidal and necrotoxic. The toxin, chemically, consisted of primary and secondary proteoses. From these experiments the earlier idea of débridement and exsanguination transfusion evolved.

In recent years Underhill, Blalock, Wilson and their respective colleagues^{6, 7, 8, 9, 10, 16, 17, 21} have attacked the tissue toxin theory vigorously. These investigators, working independently, have obtained results so convincingly harmonious that a rapidly increasing group now deny the existence of the tissue toxin entirely, and a still larger group admit that if the tissue toxin exists at all it is responsible only in part for the deleterious effects of burns. Both of these investigators point out the lack of unified opinion among the early works of Reiss,¹³ Lustgarten¹⁸ and Spietschka,¹⁹ and that the results they obtained do not occur with convincing regularity. Furthermore, very few of these investigators have been able to check the results of the others. Underhill and Kapsinow¹⁶ repeated the experiments of Robertson and Boyd exactly. They were unable to demonstrate the circulatory toxin in that the injection of whole blood from burned patients did not produce toxic manifestations in normal animals. They did, however, find the injection of an alcoholic extract of burned tissue to be toxic to normal animals but they likewise found that the injection of an alcoholic extract of normal skin was also toxic. An analysis of the extract showed enough alcohol to be present to account for the symptoms observed in the opinion of these investigators. They consequently injected into normal animals an equal quantity of ethyl alcohol and produced identical symptoms. They, therefore, concluded that the primary and secondary proteoses of Robertson and Boyd were, in reality, ethyl alcohol.

Harrison and Blalock¹⁷ grafted burned skin onto normal animals and stated that they could find no evidence of toxemia. These investigators also burned animals and found that the shortest survivals were among those débrided. They also confirmed Underhill and Kapsinow's results with whole blood injections from burned animals in that they could demonstrate no toxin.

The most convincing evidence against the tissue toxin theory, however, are the experiments of Underhill and his colleagues with burned tissue showing that, whereas burns induced an increased capillary permeability, the loss of fluid is external and that the absorption from the burned area does not take place at all for 12 hours and but very slowly for 24 hours. In these experiments the injection of methylene blue into the burned area showed no absorption into the blood stream and, more convincing, strychnine injected in lethal doses did not even produce convulsions. Certainly this is proof enough that if tissue toxin exists at all it cannot be a factor in the secondary shock stage.

Fortunately, in attacking the tissue toxin theory Underhill placed before the profession another theory to account for the secondary shock stage and produced evidence in its favor that is reasonably incontrovertible. Underhill, Carrington and Kapsinow,²⁰ in 1923, working on a number of burned cases, demonstrated the remarkable concentration of the blood which we now accept as an associate of severe burns. Experimentally Underhill and his associates have enlarged upon this observation until they have proved beyond reasonable doubt that the secondary shock stage is, in all probability, due to biochemical changes alone. As has been pointed out previously, a large group of clinicians while recognizing that these biochemical changes account for most of the phenomena observed, still insist that a toxic protein is absorbed also, and the two factors together account for the secondary shock.

As previously stated, Underhill and his associates claim and present experimental evidence to show that when an animal is burned there is an increase in capillary permeability in one direction and a decrease in absorptive power in the other. In other words fluid pours rapidly from the capillaries out into the intercellular spaces and onto the surface whereas no reabsorption takes place in the burned area for 12 hours and then very slowly for 24 hours. They have measured and analyzed this fluid. It is estimated by these investigators that, by comparison to the experimental animal, a man weighing 150 pounds with one sixth of his body surface burned will lose 3500 cc. of fluid in the first 24 hours and that the fluid lost is furthermore directly proportional to the surface area involved. With these figures in mind it is readily seen that our ideas of the fluid requirements of the burned patient need revising. Furthermore, analysis of the fluid shows that it is so similar, chemically, to blood serum that for all practical purposes it could be considered identical. Also, it is shown that there are no blood chemical changes in the burned animal which could not be due to this fluid loss. As additional proof the lowering of the blood pressure follows exactly the curve of the fluid loss. Blalock²¹ confirms in his experiments the results of Underhill. The conclusion is drawn, therefore, that whereas the primary shock is due to a relative reduction of the total blood volume, the secondary shock is due to an actual reduction of the total blood volume.

The very latest of the theories concerning the deleterious effects of thermal burns is reported by Aldrich²² who generously ascribes the idea and the

resulting proof to Firor. While discounting the tissue toxin theory entirely, and admitting the probability of Underhill's blood concentration theory, this investigator believes that a bacterial toxin is responsible for a good proportion of the systemic manifestations of burns. It is difficult to classify this theory in either the second or the third stage of the burn phenomena, as Aldrich claims it accounts partly for the symptomatology of the second stage and entirely for the symptomatology of the third stage. He cites in proof of the existence of this bacterial toxin in the stage of secondary shock that burned patients succumb during this period even when the concentration of the blood has been restored to within normal limits. However, as Brandon and Hillsman²³ have pointed out, the restoration of the blood to normal concentration of red cells in the second stage is usually accomplished by the injection of isotonic saline intravenously and such therapy does not take into consideration the serum protein deficit. The lowering of the serum protein content of the blood alone is sufficient to cause shock-line symptoms and death, even in the presence of a normal concentration of the blood as estimated by the red cell count and hemoglobin index.³⁶ However, Aldrich²² took cultures of the burned area before beginning treatment and repeatedly at intervals afterward. For the first 12 hours the cultures were sterile but after this period had elapsed the cultures were invariably positive. In the fatal cases hemolytic streptococci were found in the heart blood and in the lungs. From this theory Aldrich evolved the gentian violet treatment which is rapidly coming into favor.

The third stage of burn symptom is generally admitted to be due to bacterial infection and (Aldrich notwithstanding), is not invariably present. This is a comparatively late stage and the complications of burns usually appear during it.

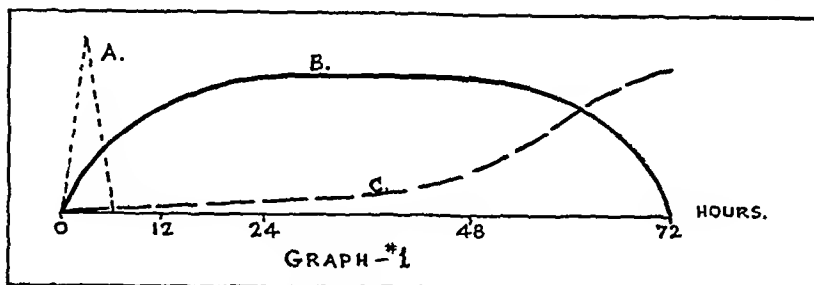
With the foregoing discussion one can readily see that the phenomena of severe burns must be visualized as a sequence of events, and that the physiologic and biochemical changes occur in an orderly manner. At the onset of a thermal burn several things occur. First there are pain and fright which may induce reflex shock, represented by a line A (Graph 1). Coincidentally an increase in capillary permeability is induced with loss of fluid. This starts immediately, reaches its peak in 24 hours, is stationary for 24 hours, and then is slowly reabsorbed. This is represented by line B (Graph 1). At the same time bacterial contamination occurs which may become active infection in 36 to 48 hours and induce toxic symptoms. This is represented by line C (Graph 1). If one believes in the tissue toxin theory its place in the sequence would be represented by B as seen in Graph 2.

If the Aldrich theory of bacterial toxicity is to be considered, then it must be combined with Underhill's blood concentration theory and would be represented by line C (Graph 3).

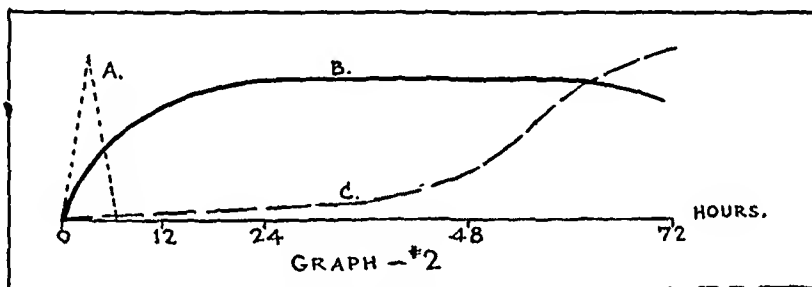
In summarizing the sequences, the author, while leaning strongly to the sequence as represented in Graph 1, gives all the possibilities because when

the therapeutic régime he advocates is outlined it will be seen that the possibilities of all three sequences will be taken into consideration.

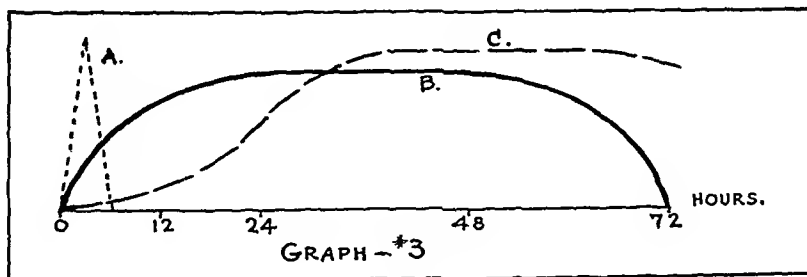
PATHOLOGY.—The examination of postmortem material shows conclusively that the pathologic changes induced by severe burns are not confined



solely to the local and obvious lesion. Depending upon the extent and severity of the burn there are very definite lesions produced in almost every organ in the body, lesions which may in the final analysis be responsible for the death of the patient. Certain of these systemic changes are relatively



easy to explain, such as the characteristic amyloid changes which occur late in burns as the result of long continued suppuration. Other lesions, however, are more difficult to understand and numerous explanations have been offered. The more important of these theories are the reflex, the blood concentration, the tissue toxin and the bacterial toxin already discussed.



The variations in the character of the local lesion in burns depend upon a number of factors, the more important of which are, the intensity, character, and duration of the heat. According to the local changes observed heat burns have been divided into degrees. These degrees are necessarily arbitrary and in actual clinical work not clearly defined. Some authors will describe only three degrees while others describe as many as six. For a

classic description of both the local and general pathology of burns one may refer to the monograph of Pack and Davis.²⁴

First Degree.—This consists of a simple erythema with vascular reactions similar to that of any simple inflammation due to the action of an irritant. It is essentially a reflex and exudative reaction. The reflex phase consists of contraction followed by dilation of the arterioles and venules, resulting in an increased flow of blood to the affected area and a local stagnation of the current. This naturally causes the redness and increased heat invariably associated with this type of burn. The exudative reaction is explained by an increased capillary permeability and consists of filtration of plasma into the tissue spaces, the migration of leukocytes, and the diapedesis of red blood cells. Within a few days the outer layer of the epidermis separates and peels off.

Second Degree.—This is essentially the degree of vesication. The epidermis undergoes true coagulation necrosis. By virtue of the increased capillary permeability there is an exudation of serous fluid and filtration of leukocytes from the tips of the papillae, resulting in the formation of blebs or bullae. In mild cases the exudation occurs within the epidermis and leaves the basal cell layer intact, thus forming the bleb. In the more severe cases the fluid collects in larger amounts beneath the full thickness of the epidermis, resulting in the larger and more serious bullae. In the very severe cases the fluid may even resemble plasma and in such cases organization of the fibrinous exudate is more likely to follow than absorption. Such blisters should be evacuated before organization occurs. It is well to remember that in this type of burn scarring may take place, particularly if infection complicates the picture.

Third Degree.—In this the epidermis is entirely destroyed as is part of the corium. Its distinguishing factor is that the interpapillary processes remain intact. The papillae appear as a reticular framework containing serum, bits of persistent living epithelium, leukocytes and fibrin. These papillae show as red points on a white background. Two things should be noted about this type of burn. First, the exposed nerve ends in the interpapillary processes remain intact and as a consequence this is the burn accompanied by the most severe pain. Secondly, the sebaceous glands, the hair follicles and the sweat glands are intact and will regenerate new epithelium providing infection does not destroy their epithelial cell lining.

Fourth Degree.—In this there is destruction of the entire thickness of the integument and complete disorganization of the skin involved. If the traumatizing factor is dry heat this area will vary from brown to black in color, be insensitive and leathery to touch. If on the contrary moist heat is the agent the affected area will be white, insensitive and finger pressure will not induce the usual color changes. Surrounding this zone will be areas of lesser degree burns, shading off from the third degree to the simple hyperemia of the first degree. An acute inflammatory process starts very early and the eschar retracts leaving a groove between the dead and living tissues.

Sloughing of the dead tissue begins and is completed normally within two weeks. At the same time proliferation occurs. Fibrinous exudation upon the surface exerts a chemotactic action upon the new tissue cells. The capillaries proliferate tufts of endothelial cells accompanied by new growth of fibroblasts, to grow along the fibrinous framework after the manner of healing by secondary intention. The endothelial cells hollow out to form arches of new capillaries giving nourishment to the growing tissue. Scarring and contracture deformities result.

Fifth Degree.—This type of burn varies only from the fourth degree in that the underlying muscles are involved. The resulting scar is, as a consequence, more deforming and may cause great functional impairment. The scar has a great tendency to break down and ulcerate.

Sixth Degree.—In this degree the tissues are carbonized and the heat may even fracture the underlying bone. It is usually seen in the very severe type of burn involving the digits and demands, invariably, amputation of the part.

The pathology of the internal organs is not by any means characteristic in burns. It has been noted that the changes were similar to those found in the acute infectious diseases of the skin. At necropsy the following systemic changes have been noted.

Central Nervous System.—Hyperemia of the brain and meninges with small minute hemorrhages into the brain substance and engorgement and thrombosis of the veins of the arachnoid.

Kidneys.—Marked changes are found in the kidneys. Acute glomerulitis is an early finding with cloudy swelling and fatty degeneration appearing later in the proximal convoluted tubules. Thrombi have been noted in the vessels, particularly in the glomerular tufts. Necrotic areas are found in the more severe degrees of burns and hemoglobin occurs throughout the renal cortex to give the kidney the brownish-red color seen almost invariably in fatal burns.

Suprarenal Glands.—The pathologic findings in these organs are most interesting because attempts have been made to ascribe the fatal effect of burns to disturbance of their function. The normal weight of the suprarenal gland is from four to seven Gm. and in the severely burned case it often weighs from 20 to 25 Gm. Experimentally within 24 hours there is marked hyperemia and occasional hemorrhages noted in the glands. The perirenal fat is markedly edematous. Later the glandular cells are swollen, hydropic and frequently show necrosis.

Spleen.—The spleen is enlarged and shows focal necrosis in the germinal centers of the lymph nodules. The endothelial cells proliferate rapidly to occupy the germinal centers and may fuse to form giant cells. Later hyaline degeneration of the lymph nodules may be seen.

Heart.—This organ in the late severe cases shows hyaline and fatty degeneration with necrosis of the muscle fibers.

Liver.—Parenchymatous degeneration with focal necrosis and hyperemia is usually seen in this organ.

Lungs.—In fatal cases of burns the lungs are found congested with thrombi in the smaller branches of the pulmonary artery. Focal pneumonia is usually present.

Lymph Nodes.—The usual lesion seen in the lymph node is central necrosis of the follicles with endothelial proliferation.

Gastro-Intestinal Tract.—Hyperemia is noted throughout the gastro-intestinal tract with petechial hemorrhages into the mucosa. Ulcerations may occur anywhere along the tract but are found most frequently in the duodenum.

COMPLICATIONS.—In discussing the complications of thermal burns one might justly say that all complications begin with and include the third stage. Since in the preceding outline it was stated that the third stage was that of infection and (Aldrich notwithstanding), was not an invariable sequence of all burns, then the occurrence of infection itself could be classed as a complication. The very character of the trauma naturally produces a lesion which is at first sterile. However, in a burn involving any great extent of the body surface it is manifestly impossible to prevent subsequent contamination. Whether this contamination goes on to actual infection depends upon a number of well known factors. It is certain that a high percentage of severe burns do reach the actual stage of infection and a goodly proportion actively suppurate. The presence of necrotic tissue as an excellent culture medium together with inevitable bacterial contamination makes this easily understandable. To keep bacterial contamination at a minimum and to take every precaution against its occurrence constitutes one of the chief aims in the therapy of burns. It lessens the frequency of development of the following complications:

Septicemia.—This complication, while reported rarely, may well occur more frequently than is realized. Aldrich²² found streptococci in the heart's blood of all his fatal cases of burns.

Erysipelas and Tetanus.—Both of these conditions complicate burns but fortunately occur in only a small percentage of cases.

Hemorrhage.—Hemorrhage occurs in a small percentage of cases and is usually met with only in dirty, sloughing, badly infected burns. It occurs from the superficial veins and infected granulation tissue. Since the burned patient is usually in poor condition when this complication occurs it is quite serious.

Bedsore.—Bedsore are seen in burned cases among the aged and those cases who are bedridden over long periods without proper prophylactic attention. This complication is also fortunately rare.

Pneumonia.—Pneumonia is one of the more common complications in fatal cases of burns. In those cases dying late in the course of the sequence, pneumonia or nephritis are the usual cause of death.

Nephritis.—Kidney damage occurs early in the sequence of burns. In fact, so regular and so early does this complication occur it may be taken as a part of the phenomena of burns and not classified as a complication. The

early occurrence of kidney damage warns us that unguarded intravenous fluid therapy after 48 hours may be dangerous. The early kidney damage may be accounted for by any of the numerous theories advanced but the late stage is undoubtedly due to bacterial toxicity.

Amyloid Degeneration.—Amyloid degeneration is not a peculiarity of burns but is found in this condition, as elsewhere, after long-continued suppuration.

Curling Ulcer.—Although ulcers have been reported throughout the gastro-intestinal tract following burns, the more common location is in the duodenum. This variety of ulcer is one of the more interesting and inexplicable facts we have in surgery. It was first described by James Long²⁵ in 1840 and later by Curling²⁶ in 1842. Although they are rarely reported in the literature they probably are, in reality, a frequent complication. Perry and Shaw²⁷ reported duodenal ulcers as being routinely found in 0.4 per cent of all cases coming to autopsy and in 3.3 per cent of all persons autopsied after severe burns. Since these ulcers do not produce symptoms unless perforation or hemorrhage occurs and since the mortality under these conditions is given as 100 per cent, then it is reasonable to suppose that a fair number occur which do not come to the attention of the attending physician. This becomes more reasonable when upon investigation it is found that these ulcers rarely become chronic but either perforate or heal.

The mechanism of its production is still unknown. Numerous theories have been advanced. Curling²⁶ believed hyperactivity of Brunner's glands to be responsible. Hunter²⁸ thought emboli to be the etiologic factor. Many others have attempted the explanation but with inadequate proof. The more recent explanation of the ulcerations being caused in some manner by suprenal damage deserves mention.^{29, 30, 31} Many have attempted the explanation from this viewpoint but so far the proof is not convincing.

Treatment of the Acute Stage.—The treatment of severe burns is very properly divided into the local and the systemic. In reviewing the literature one immediately notices that the controversy seems to center for the most part around the local treatment. Much has been written proving or disproving the value of the tannic acid, the débridement, or the gentian violet treatment of burns, and it is the rule rather than the exception to find the systemic treatment dismissed very briefly. The author wishes to state emphatically that he believes the systemic treatment to be the main pillar in the therapy of burns, and that the variations of the local treatment are, by comparison, emphasized far too much.

The systemic therapy of burns consists in actively combating the primary shock and in anticipating and restoring the fluid loss certain to follow the injury through increased capillary permeability. The treatment of the primary shock is the judicious employment of opiates to keep the patient as free as possible from pain and to promote tranquillity of the mind. Heat in the form of the electric crib is used to combat heat dissipation and to restore normal temperature. The head of the bed is lowered and an intra-

venous injection of isotonic saline is given to combat the relative reduction of the total blood volume. The amount of saline injected intravenously during the stage of primary shock should be a quantity equal in amount to the patient's total blood volume. In a man weighing 150 pounds it is thought this would amount to 5,000 cc. By rapidly injecting this amount of saline intravenously, the relative blood volume is apparently restored. When the tone of the capillary bed recovers, the circulation will have an excess quantity

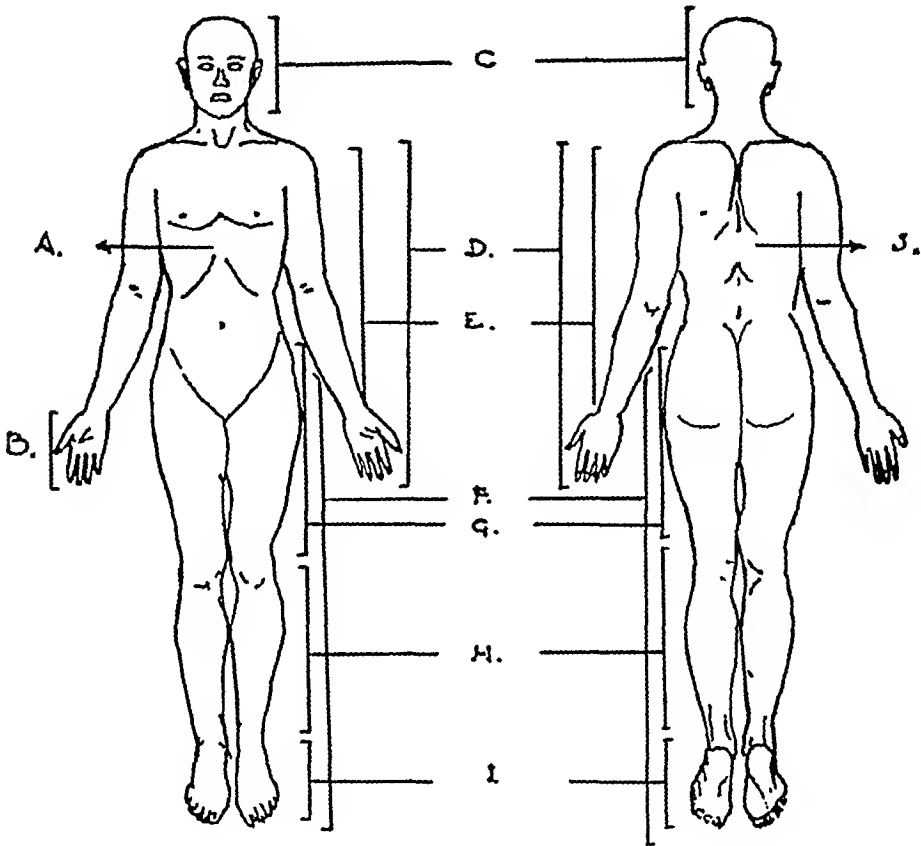


FIG. 1.—Showing method of estimating the percentage of the area burned by use of the Berkow scale.

A—Anterior surface of trunk.....	20%
B—Total surface both hands.....	4½%
C—Head	6%
D—Total surface, upper extremities complete	18%
E—Total surface, both arms and forearms.....	13½%
F—Total surface, lower extremities complete.....	38%
G—Total surface, both thighs	19%
H—Total surface, both legs	13¾%
I—Total surface, both feet	6⅓%

To ascertain the proportions at a given age, the following rule is proposed: the trunk is 40 per cent, the upper extremities, 16 per cent. For the head and lower extremities, subtract the age (in years) from 12 and add the remainder to the number expressing the adult proportion for the head (6 per cent). Subtract the same amount from the number expressing the adult proportion (38 per cent) for the lower extremities.

of fluid present to combat the gradual loss of serum now to ensue due to the increased capillary permeability. These measures should successfully combat the primary shock. The restoration of the fluid lost from increased capillary permeability is merely a question of the quantity and kinds of fluid one should give the patient. The quantity is determined in two ways, first, the surface area involved, and, secondly, the variations of the red blood cell count and hemoglobin index. Bearing in mind the experiments of Under-

hill, that an animal with one-sixth of the body surface burned would lose in the first 24 hours fluid equivalent to 70 per cent of its total blood volume and that this in an adult weighing 150 pounds would amount to 3,500 cc., one has a basis for quantitative estimation. As has been stated before, the fluid loss is directly proportionate to the surface area involved. A rough estimate of the area burned can be made by using the Berkow scale³² (Fig. 1). By following the red blood cell count and the hemoglobin index taken each time from the same site one has a much simpler way of estimating the degree of blood concentration and the patient's fluid requirements. In following the latter method the general rule should be to force fluids, no matter to what quantity, until the blood concentration is restored to normality. The fluids should be subsequently forced in sufficient quantities to maintain blood concentration within normal limits. During the first 48 hours following a burn, when it can be reasonably assumed that the patient's heart and kidneys are functionally normal, there is no danger in forcing isotonic fluids in any quantity. This has been adequately proven by Smith and Mendel³³ who have shown that the excess fluid is eliminated by the kidneys without harm to the animal organism as rapidly as it is possible to inject it. Since an extensive burn renders subcutaneous injection of fluids almost impossible the intravenous route is the method used almost entirely. The oral and rectal routes, however, should not be neglected.

The kinds of fluids to be used present another problem. Since Underhill and his associates have proven that the fluid lost is almost analogous to blood serum, it is obvious that the ideal fluid would be blood serum. To give this fluid in the quantity required would be obviously impossible. The normal saline solution approaches nearer the nature of blood serum than any other fluids commonly used.³⁴ It contains the water necessary to restore blood volume. It contains the sodium and chlorine ions so important to the maintenance of the acid-base equilibrium and the electronic concentration.³⁵ However, it must be emphasized again that saline solution alone is inadequate to the proper restoration of blood volume. The serum protein lost in the burned area must be restored in order that the colloidal content of the blood stream will be sufficiently high to prevent the saline injected from diffusing out into the tissue spaces.²³ Too often we see the burned patient die with a concentrated blood while his peritoneal cavity shows free fluid at postmortem. Furthermore, reduction of the serum protein content of the blood has in itself been proven to be dangerous and even fatal.³⁶ The simplest way to restore serum protein lost is by blood transfusion. At least 1,000 cc. of blood should be given to adult patients in the first 24 hours and, in the extensively burned case, more than this should be given if it is feasible.

In analyzing the various methods used in the local treatment of burns one finds that the controversy is more apparent than real. The clinics advocating the tannic acid treatment admit the possibility of infection and in using tannic acid sprays to combat the absorption of the tissue toxin and also to prevent the escape of plasma and water they consciously or unconsciously

practice the chemical débridement taught by the bacterial toxin school. Thus it is easily possible for one to believe in the bacterial toxin theory and still use the tannic acid spray. On the other hand, the clinics advocating the bacterial toxin theory use gentian violet solution as a bactericide and in doing so precipitate protein which forms an eschar. This eschar is likewise chemical débridement and would also retard the absorption of a tissue toxin should it be present. It is easy to see, therefore, why so many authors avoid controversy by admitting the possibility of both toxins because, in the practical treatment of burns, either tannic acid or gentian violet can be used irrespective of which type of toxin one believes in. If, on the other hand, the clinician believes in the existence of neither toxin, and believes that the secondary shock stage of burns is purely the result of fluid loss, there still remain reasons why he should use either the tannic acid or the gentian violet spray. Firstly, the use of either of these sprays will form an eschar which decreases pain. Secondly, it is easily possible that the precipitation of protein to form the eschar may lessen fluid loss by the early establishment of the electronic balance. Thirdly, the chemical débridement caused by either solution lessens the possibility of bacterial contamination becoming an infection and is far superior to any form of mechanical débridement in preventing the third (infectious) stage of burns.

In the local treatment of burns the author believes that, whereas either tannic acid or gentian violet may be used, the gentian violet solution has certain advantages which should be considered. Both tannic acid and gentian violet solution will precipitate protein to form an eschar which decreases pain, chemically débrides, and lessens absorption, but gentian violet is more bactericidal than tannic acid, and the eschar formed is more soft and pliable. Particular attention should be paid to this latter advantage as it permits the early palpation of accumulations of pus beneath the eschar and easy evacuation. The early evacuation of pus pockets beneath the eschar protects the epithelium of the hair follicles, and the sebaceous and sweat glands from destruction. As it has been adequately proven that regeneration of skin takes place from these sources, this is obviously of great importance in the reconstruction phase.³⁷

The local treatment begins with the admission of the patient. The burned area should be cleansed of all foreign matter and mechanical débridement carried out as far as is compatible with the patient's general condition. The burned case should be placed upon sterile sheets beneath an electric crib and either the tannic acid or gentian violet spray used. If the tannic acid spray is to be used the aqueous solution should be freshly prepared. The strength varies from 2.5 per cent as originally used by Davidson¹¹ to 10 per cent as used by Mason³⁸ and Mitchiner.¹² The spray is used every 15 minutes until a brownish-black eschar is formed and then every hour until 48 hours have passed. If the gentian violet spray is used the solution should be 1 per cent in water and applied every one to two hours until the eschar is formed, then every four to six hours until healing is complete.²² Fatherree,

Kennedy and McSwain³⁹ have altered this treatment by making a gentian violet jelly which is spread upon sterile cloths and applied. The jelly consists of 1,000 cc. of a 1 per cent aqueous solution of gentian violet and 30 Gm. of tragacanth. This jelly, it is claimed, rarely has to be applied more than once. In situations where adequate nursing care is impossible this modification may be considered. Irrespective of which solution is used the eschar should be watched carefully after 48 hours for accumulations of pus and such accumulations promptly evacuated and Dakin's dressings applied.

SUMMARY

(1) The various theories concerning the ill effects of burns have been analyzed and an attempt has been made to show that the phenomena associated with burns are in reality a sequence of events.

(2) The pathology and complications of burns have been discussed.

(3) The treatment of severe burns has been given on the basis that the associated phenomena are a sequence of events. The treatment has, furthermore, taken into consideration the fact that any or all of the various theories concerning burns may be correct.

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THE BLEEDING VOLUME IN SEVERE BURNS

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ROOME, KEITH, and PHEMISTER¹ showed that the methods by which experimental shock could be produced may be divided into two groups, dependent on the bleeding volume. In the first type, produced by hyperventilation, anaphylaxis, histamine administration, spinal cord section, or spinal anesthesia, the bleeding volume was large. In 28 dogs it averaged 49.9 per cent of the calculated blood volume. This is only slightly less than the average of 58.6 per cent obtained for a series of 20 control dogs. On the other hand, in the second group, due to trauma to an extremity, hemorrhage, plasmapheresis, or intestinal manipulation, the bleeding volume was greatly reduced, averaging 21.8 per per cent in 22 dogs. The blood pressure was reduced in the 50 shock experiments to levels usually between 50 and 70 Mm. of mercury and the animals were usually bled to death approximately one hour after the initiation of the procedure. The 20 anesthetized control dogs were bled to death at the end of one hour. The action is in the first group mainly the result of peripheral vasodilatation and in the second group mainly of reduction in circulating blood volume.

This differentiation of shock into two types on the basis of bleeding volume and blood pressure is in accord with the work of Blalock and his associates on the basis of cardiac output and blood pressure. Blalock² attempted to produce primary shock by striking the abdomens of ten well-anesthetized dogs many blows in rapid succession with the flat surface of a board for approximately two minutes. If free hemorrhage into the peritoneal cavity resulted from the traumatization, the experiment was discarded. In all ten animals the striking of the abdomen was followed by a decline of blood pressure varying from 38 to 75 Mm. of mercury. Associated with the drop in blood pressure, the cardiac output as measured by the Fick method increased slightly in seven animals and decreased in three. Johnson and Blalock³ found that the introduction of histamine causes an initial decline in the blood pressure followed by a decrease in the cardiac output. Blalock and Beard⁴ found that the removal of the adrenal glands usually causes a decline in blood pressure before the cardiac output is lowered. Blalock and Bradburn⁵ found that trauma to the central nervous system is usually associated with a simultaneous decline in both the cardiac output and blood pressure. In addition, Butler, Beard, and Blalock⁶ found that following the subcutaneous injection of histamine in dogs there was a decrease in the blood volume as determined by the dye method. Blalock's

results in general indicate that in primary types of shock, the cardiac output does not decrease until the blood pressure falls. The time relation between these two factors and the blood volume has not yet been worked out completely.

In the so called secondary types of shock, Blalock and his co-workers have found that in general the decrease in cardiac output precedes the decline in blood pressure. Blalock⁷ found that repeated removal of blood was usually associated with a decline in the cardiac output from 30 to 50 per cent below the normal level before a marked diminution in the blood pressure occurs. Johnson and Blalock³ found that secondary shock as a result of trauma to muscles, trauma to the intestines, or burns is associated with a definite decrease in the cardiac output before the blood pressure falls appreciably. No reports of the bleeding volume in experimental burns have been found.

METHOD

Dogs under complete anesthesia were used in all experiments and none that were burned were allowed to recover. They were weighed after catheterizing the urinary bladder and anesthetized with sodium barbital (260 mg. per kg. body weight intraperitoneally). The hair was removed from the body and extremities of the animals by the use of either fine clippers or a razor. The longitudinal midlines of both the dorsal and ventral surfaces were marked with India ink. The blood pressure was determined by placing in the carotid artery a cannula which was connected to a mercury manometer. Hemoglobin determinations were made by the Sahli method and hematocrit readings with the Van Allen hematocrit. The animals were then burned over a period varying from six to ten minutes by the direct application of the Bunsen flame. Only one side, usually the right, was burned with most of the burning over the region of the thigh, groin, axilla and shoulder. The blood pressure was determined intermittently until it had fallen to the desired level. The animals were then bled rapidly to death and the amount of blood obtained was measured. Bleeding was by the carotid arterial cannula, the animal being left in the horizontal position and the cannula kept free from clots. In all animals, tipping of the hind end up after bleeding had ceased caused no more blood to flow. In certain animals cannulization of the other carotid artery after bleeding had ceased caused no more blood to flow. The bleeding volume thus obtained is presumed to be an approximate index of the circulating blood volume, and will be described in this paper as a percentage of the calculated blood volume ($1/13$ th of the body weight). The entire animal was then weighed to determine the total weight loss. This total weight loss was then corrected so as not to include the blood lost by bleeding and any urine or feces which were passed during the experiment. The animal was then bisected up to the neck by the method described in the first paper of this series,⁸ the two halves weighed and the

TABLE I

Summary of Results in Six Burned Animals in Which the Blood Pressure was Allowed to Fall Near a So Called Shock Level before the Bleeding Volume Was Obtained. Animal No. 3 Was Burned an Additional Five Minutes at the End of 13½ hours

Experiment	Time of Observation after Burning	Weight of Animal kg.	Loss in Weight gm./kg./hr.	Mean Blood Pressure Mm. of Hg.	Hemo-globin Per Cent	Hematocrit	Weight Burned Side Animal kg.	Weight Unburned Side Animal kg.	Difference in Weight Two Sides as Per Cent Body Weight	Terminal Bleeding	
										Volume,	Per Cent of Calculated Blood Volume
1	Control period.....	10.408	—	100	105	53	—	—	—	—	—
	5 hours.....	—	—	102	—	—	—	—	—	—	—
	10 hours.....	—	—	100	118	60	—	—	—	—	—
	17½ hours.....	10.118	1.5	50	119	64	3.246	2.933	3.0	—	11.9
2	Control period.....	9.212	—	148	111	53	—	—	—	—	—
	4 hours.....	—	—	110	—	—	—	—	—	—	—
	9 hours.....	—	—	96	132	62	—	—	—	—	—
	16 hours.....	8.746	3.2	44	134	64	2.813	2.583	2.5	—	14.6
3	Control period.....	7.835	—	116	110	53	—	—	—	—	—
	3 hours.....	—	—	84	—	—	—	—	—	—	—
	4½ hours.....	—	—	88	—	—	—	—	—	—	—
	7 hours.....	—	—	84	108	53	—	—	—	—	—
	8½ hours.....	—	—	86	—	—	—	—	—	—	—
	13½ hours.....	—	—	96	—	—	—	—	—	—	—
	16 hours.....	—	—	100	—	—	—	—	—	—	—
	17 hours.....	7.365	3.5	48	126	65	1.950	1.927	0.3	—	16.1

BLEEDING VOLUME IN BURNS

4	Control period.....	10.493	—	164	99	47	—	—	—	—	—
	4½ hours.....	—	—	162	130	58	—	—	—	—	—
	11½ hours.....	—	—	142	130	64	—	—	—	—	—
	15 hours.....	—	—	116	139	62	—	—	—	—	—
	19½ hours.....	—	—	82	130	63	—	—	—	—	—
	21½ hours.....	10.267	1.0	62	125	60	3.327	3.216	1.1	16.7	—
5	Control period.....	12.086	—	148	104	49	—	—	—	—	—
	3½ hours.....	—	—	140	140	64	—	—	—	—	—
	11 hours.....	—	—	126	153	69	—	—	—	—	—
	14 hours.....	—	—	114	154	70	—	—	—	—	—
	19 hours.....	—	—	90	156	72	—	—	—	—	—
	21 hours.....	—	—	86	—	—	—	—	—	—	—
	22½ hours.....	—	—	84	—	—	—	—	—	—	—
	24 hours.....	11.482	2.2	82	162	70	3.898	3.518	3.0	14.0	—
6	Control period.....	6.855	—	118	106	48	—	—	—	—	—
	6 hours.....	—	—	120	132	66	—	—	—	—	—
	10½ hours.....	—	—	113	131	66	—	—	—	—	—
	14 hours.....	—	—	88	137	68	—	—	—	—	—
	15½ hours.....	—	—	80	—	—	—	—	—	—	—
	16 hours.....	—	—	76	—	—	—	—	—	—	—
	18 hours.....	6.712	1.2	62	134	68	2.211	2.047	2.4	24.6	—
Average.....		—	2.1	—	—	—	—	—	2.1	16.3	—

difference in weight obtained. Control animals were treated exactly the same except that they were not burned.

RESULTS

Fifteen experiments were performed. These represent three groups: (1) Six burned animals in which the blood pressure was allowed to fall to near a so called shock level (varying from 44 to 82 Mm. of mercury) before the bleeding volume was determined; (2) five burned animals in which the bleeding volume was determined before the blood pressure had fallen near a so called shock level; and (3) four control animals. The results of these three groups of experiments are shown in Tables I, II and III. These results are discussed under the following six heads: (a) Duration of experiment; (b) total weight loss during experiment; (c) fall in mean arterial blood pressure; (d) rise in hemoglobin percentage and hematocrit reading; (e) local accumulation of fluid in the burned tissues as shown by the difference in weight of the burned and unburned sides; and (f) the terminal bleeding volume in terms of per cent of the calculated blood volume.

(a) *Duration of Experiment.*—The time necessary to reduce the blood pressure to approximately a shock level varied in six dogs from 16 to 24 hours, averaging 17.3 hours. This places the reaction well within the confines of secondary shock, irrespective of whether the time or the etiologic definition of secondary shock is used. The time that was allowed to elapse in the case of the five animals that were bled before the blood pressure had fallen to near a shock level varied from five to 24 hours, averaging 11 hours. Since, in the experiments of Roome, Keith and Phemister,¹ the bleeding volume in both the shock and control animals was usually determined only an hour after the initiation of the procedure, it was thought necessary to determine the bleeding volume of control dogs after a longer interval. Hence, four anesthetized control animals were bled from 15½ to 24 hours, averaging 18.9 hours after the beginning of the experiment. The bleeding volume of these four control animals averaged only slightly less than that of Roome, Keith and Phemister's ten dogs bled at the end of only an hour. Also because the present experiments were of longer duration than those of the authors mentioned, it is not strictly accurate to compare the bleeding volume in burn shock with that in other types of shock as determined in their paper.

(b) *Total Weight Loss During Experiment.*—Roome and Wilson⁹ showed that the weight loss in five control dogs, observed over a period of 46.2 hours, amounted to 1.9 Gm. per kg. body weight per hour. It was shown in a previous paper⁸ that the weight loss in three burned animals observed over a period of from four to ten hours averaged 2.5 Gms. per kg. per hour. In Table I it is seen that in six burned animals observed over a period of from 16 to 24 hours the total weight loss averaged 2.1 Gm. per kg. per hour. The single reading shown in Table II raises this average to 2.2 Gm. per kg. per hour for seven burned animals. This agrees rather well

TABLE II

Summary of Results in Five Burned Animals in Which the Bleeding Volume Was Determined before the Blood Pressure Had Fallen Near a So Called Shock Level. Animal No. 7 Was Burned an Additional Five Minutes after 14½ Hours, Three Minutes after 22 Hours and 13 Minutes after 24 Hours. The Fluid Shift Shown in the Next to the Last Column for Experiments No. 8 and No. 9 Is Not Included in the Average Because Part of the Fluid Had Leaked Out of the Burned Tissues before Weighing.

Experiment	Time of Observation after Burning	Weight of Animal kg.	Loss in Weight in Gm./kg./hr.	Mean Blood Pressure Mm. of Hg.	Hemo-globin Per Cent	Hematocrit	Weight Burned Side Animal kg.	Weight Unburned Side Animal kg.	Difference in Weight Two Sides as Per Cent Body Weight	Terminal Bleeding Volume, Per Cent of Calculated Blood Volume
7	Control period.....	11.255	—	145	106	49	—	—	—	—
	3½ hours.....	—	—	150	—	—	—	—	—	—
	8 hours.....	—	—	140	149	67	—	—	—	—
	14½ hours.....	—	—	116	141	64	—	—	—	—
	20 hours.....	—	—	106	—	—	—	—	—	—
	22 hours.....	—	—	92	—	—	—	—	—	—
	23 hours.....	—	—	102	—	—	—	—	—	—
	24 hours.....	—	—	108	149	70	3.475	3.225	2.2	29.3
8	Control period.....	8.455	—	140	106	49	—	—	—	—
	5½ hours.....	8.331	2.7	106	126	63	2.422	2.319	1.2	49.2
9	Control period.....	14.0	—	140	99	46	—	—	—	—
	3 hours.....	—	—	136	148	68	—	—	—	—
	5 hours.....	—	—	114	132	63	4.217	4.052	1.2	22.3
10	Control period.....	24.5	—	132	105	51	—	—	—	—
	2½ hours.....	—	—	126	126	58	—	—	—	—
	6½ hours.....	—	—	114	131	66	—	—	—	—
	10½ hours.....	—	—	102	132	58	8.585	7.788	3.3	21.1
11	Control period.....	25.0	—	140	98	45	—	—	—	—
	1½ hours.....	—	—	130	103	48	—	—	—	—
	6 hours.....	—	—	138	112	54	—	—	—	—
	10 hours.....	—	—	130	146	—	8.516	7.649	3.5	35.4
Average.....	—	—	2.7	—	—	—	—	—	3.0	31.4

TABLE III

Summary of Results in Four Anesthetized Control Animals that Were Not Burned

Experi- ment	Time of Observation	Weight of Animal kg.	Loss in Weight in Gm./kg./hr.	Mean Blood Pressure Mm. of Hg.	Hemo- globin Per Cent	Hemat- ocrit	Weight Right Side Animal kg.	Weight Left Side Animal kg.	Difference in Weight Two Sides as Per Cent	Terminal Bleeding Volume, Per Cent of Calculated Blood Volume
12	Onset.....	24.0	—	154	86	40	—	—	—	—
	10 hours.....	—	—	142	88	42	—	—	—	—
	14½ hours.....	—	—	128	78	40	—	—	—	—
	24 hours.....	—	—	128	67	33	6.948	6.920	0.12	49.8
13	Onset.....	12.975	—	134	109	54	—	—	—	—
	9½ hours.....	—	—	138	113	52	—	—	—	—
	14 hours.....	—	—	132	103	49	—	—	—	—
	17½ hours.....	12.711	1.2	136	103	49	—	—	—	52.0
14	Onset.....	12.070	—	136	112	48	—	—	—	—
	9 hours.....	—	—	130	113	49	—	—	—	—
	13½ hours.....	—	—	120	112	47	—	—	—	—
	15½ hours.....	11.922	0.8	102	91	41	3.643	3.620	0.19	47.2
15	Onset.....	19.5	—	118	85	43	—	—	—	—
	9 hours.....	—	—	124	84	41	—	—	—	—
	18½ hours.....	—	—	116	91	42	—	—	—	64.7
Average.....		—	1.0	—	—	—	—	—	0.16	53.4

with the figure of 2.5 reported in the previous paper. The average of 1.0 Gm. per kg. per hour for two control animals shown in Table III agrees fairly well with the figure of Roome and Wilson. The importance of these figures is that they indicate there is little more weight loss from all causes in the burned than in the unburned control animals. This would in turn support the theory that in dogs an internal fluid imbalance is the important factor in the causation of burn shock. In the human being there is the additional factor of weeping from the burned skin, whereas a dog's skin is essentially tanned and dry immediately after burning.

(c) *Fall in Mean Arterial Blood Pressure.*—In the six experiments shown in Table I, the mean arterial blood pressure was allowed to fall to 50, 44, 48, 62, 82, and 62 Mm. of mercury respectively. All but the reading of 82 is below the so called shock level of blood pressure (70 Mm. of mercury). The average blood pressure at the end of the six experiments was 58. Since the average initial blood pressure in these six experiments was 133, the final reading represents an average fall of 75 Mm. of mercury. In the five experiments in which the bleeding volume was determined before the blood pressure had fallen near a so called shock level, the average initial mean arterial blood pressure was 141 and the average final reading was 113, representing a fall of 28 Mm. of mercury. In the four anesthetized control dogs that were not burned the average initial pressure was 135, the average final pressure 120, and the average fall 15 Mm. of mercury.

(d) *Rise in Hemoglobin Percentage and Hematocrit Reading.*—In the six burned animals that were bled after the blood pressure had fallen appreciably, the average readings at onset were 106 per cent for the hemoglobin and 50 per cent for the hematocrit. The highest readings after burning averaged 136 and 66 which represent an increase of 30 in the per cent of hemoglobin and 16 in the hematocrit readings. Similar figures from Table II are 103 and 48 at the onset, and 140 and 67 for the highest readings, representing a rise of 37 in the hemoglobin per cent and 19 in the hematocrit reading. The average hemoglobin per cent in the control experiments shown in Table III did not rise appreciably at any time, the initial reading averaging 98 and the final 88, representing a fall of 10. The hematocrit readings in these control animals showed a similar average drop of five from 46 to 41. In the nine burned animals in which sufficient readings were made to follow the course of the hemoglobin percentage, three showed a terminal decrease, five showed a terminal rise and one showed no appreciable change at the end. The hematocrit readings in general followed the hemoglobin percentage. It is possible that if readings were made more frequently a higher proportion of experiments would have shown the terminal drop.

(e) *Local Accumulation of Fluid in the Burned Tissues as Shown by Difference in Weight of the Burned and Unburned Sides.*—The amount of this accumulation was determined so as to have an index of the extent of the burn. Blalock¹⁰ showed that in nine burned dogs the fluid amounted to 3.2 per cent body weight at death. In a previous paper in this series, the

fluid in eight burned animals averaged 2.2 per cent body weight at death. In Table I it is seen that the difference in weight of the sides of the animals averaged 2.1 per cent body weight. The very low reading of 0.3 per cent in experiment three is probably due to the inaccuracy of the bisection method combined with a relatively slight burn as is evidenced by the slight changes in the hemoglobin and hematocrit readings. In three experiments shown in Table II it averaged 3.0 per cent. On the other hand, two control experiments shown in Table III showed a practically negligible difference of 0.16 per cent body weight. The figures for the burned animals indicate a fluid shift of only slightly less magnitude than that obtained by Blalock.

(f) *The Terminal Bleeding Volume in Terms of Per Cent of the Calculated Blood Volume.*—The average terminal bleeding volume in the six burned animals in which the blood pressure was allowed to fall near a so called shock level before bleeding averaged 16.3 per cent of the calculated blood volume (one-thirteenth of the body weight). The similar average for the five intermediate experiments shown in Table II was 31.4 per cent. The average bleeding volume for the four control dogs was 53.4 per cent. The decrease in bleeding volume in the first series of six animals shown in Table I was 37.1 per cent and at the same time the blood pressure fell an average of 75 Mm. of mercury. The decrease in bleeding volume in the second or intermediate series of five animals shown in Table II was 22.0 and at the same time the blood pressure fell an average of 28 Mm. of mercury. This indicates that at a time (as shown by the second series of five animals) when the blood pressure had fallen only 37 per cent of the ultimate fall (as shown by the first series of animals), the bleeding volume had already decreased 59 per cent of the ultimate amount. It is, of course, difficult to compare the results of these two series of animals. It can only be assumed that if the blood pressures of the second series of five animals had been allowed to fall as low as in the first series of six animals, the bleeding volumes would have decreased the same.

COMMENT

Five of the most important physiologic changes in burns are those in (1) blood pressure, (2) blood concentration as shown by increase in per cent hemoglobin and hematocrit reading, (3) local fluid accumulation in the tissues, (4) blood volume, and (5) cardiac output. The time relations of these five factors are of interest. The work of previous investigators^{3, 8, 10, 11} has shown that in general there is a gradual increase in local fluid accumulation, decrease in cardiac output and increase in blood concentration following experimental burns. On the other hand, the blood pressure remains near normal only to collapse rather suddenly as death approaches. Little work has been done on the blood volume following burns. This paper involves the assumption that the bleeding volume is an index of the circulating blood volume. Whether or not this assumption is justified is an open question, but the bleeding volume itself is an index of the type of shock in a given instance

as was shown by Roome, Keith, and Phemister.¹ These authors studied the bleeding volume in most of the important types of experimental shock except burns. Blalock has studied the cardiac output³ in burns and the blood volume⁶ in certain types of shock other than burns. The average bleeding volume in the 11 burned dogs was 23.2 per cent of the calculated blood volume. This agrees rather well with the figure of 21.8 obtained by Roome, Keith, and Phemister¹ for the bleeding volume in shock due to trauma to an extremity, hemorrhage, plasmapheresis, or intestinal manipulation in all of which blood volume is reduced. This would indicate that the shock resulting from burns is similar to that following these other procedures (using the bleeding volume as the basis of comparison). All of these injuries are generally recognized as producing secondary shock. On the other hand, Roome, Keith, and Phemister's average of 49.9 per cent of the calculated blood volume obtained for the bleeding volume after hyperventilation, anaphylaxis, histamine administration, high spinal cord section or spinal anesthesia indicates that these former procedures produce a type of shock dissimilar to that resulting from burns.

A comparison of the two series of burned animals supports the belief that the bleeding volume decreases more rapidly than the blood pressure following a severe burn. This agrees with Blalock's finding that bleeding gives reduced blood volume and diminished cardiac output before the fall in blood pressure. The five animals in which the blood pressure had fallen only 37 per cent of that of the other series of six animals showed a fall in bleeding volume which was 59 per cent of that of the other series. This suggests that if Roome, Keith, and Phemister¹ had determined some of their bleeding volumes before the blood pressure had fallen appreciably, they might also have found them low in shock produced by the various other causes in this group.

These changes in the bleeding volume in burns indicate that the blood concentration, local fluid accumulation, blood volume (as evidenced by the bleeding volume) and the cardiac output all follow the true course of a burn more accurately than the blood pressure which collapses only as death approaches. This suggests that clinically any of these factors may be of more importance in diagnosis and prognosis than the blood pressure. The local fluid accumulation, blood volume (most certainly the bleeding volume), and cardiac output are all difficult to determine in the human being; but the hemoglobin percentage and hematocrit reading are easy to obtain and should be more often used in the diagnosis and prognosis of burn shock. The hemoglobin percentage has been especially used in this connection by Underhill.¹²

SUMMARY

The bleeding volume in six burned dogs bled after the mean arterial blood pressure had fallen from an average of 133 to 58 (a drop of 75 Mm. of mercury) was 16.3 per cent of the calculated blood volume. At the same time the animals showed a fluid shift to the burned side of 2.1 per cent of

the body weight. The hemoglobin percentage rose from an average of 106 to 136 and the hematocrit reading from 50 to 66.

The bleeding volume in a second series of five burned animals after the mean arterial blood pressure had fallen from an average of 141 to only 113 (a drop of 28 Mm. of mercury) was 31.4 per cent of the calculated blood volume. At the same time these animals showed a fluid shift to the burned side of 3.0 per cent of the body weight. The hemoglobin percentage rose from an average of 103 to 140 and the hematocrit reading from 48 to 67.

The bleeding volume in four anesthetized control animals averaged 53.4 per cent of the calculated blood volume. The changes in the blood pressure, fluid shift, hemoglobin percentage, and hematocrit reading were all much less than those in the burned animals.

These results indicate that the bleeding volume decreases more rapidly than the blood pressure and that its rate of change is more closely related to the cardiac output, blood concentration, and local fluid accumulation. The average bleeding volume following burns is similar to that obtained by other authors in shock due to trauma to an extremity, hemorrhage, plasmapheresis, or intestinal manipulation in which the chief factor is a decrease in blood volume.

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PILONIDAL CYSTS AND SINUSES

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It is our purpose in this paper to present and analyze a series of 288 cases of pilonidal cysts and sinuses with especial reference to treatment and end-results. Pilonidal, sacrococcygeal or dermoid cyst, postanal dimple, or foveola coccygea, are congenital malformations in the sacrococcygeal region characterized by acute and chronic inflammation; the presence of tufts of hair; occasional islets of squamous epithelium and foreign body giant cells.

The first description in the literature was given by Anderson¹ in 1847, who reported a case of "hair extracted from an ulcer." Vaughn, quoted by Markoe and Schley,² reported three cases of "pilous cysts" in 1865. Warren^{3, 4} in 1867 named the condition pilonidal cyst, although he had described some cases previously in 1854. They were mentioned and described as medical curiosities, frequently, a few cases at a time, from this time on, but practically all the literature up to 1900 dealt with the embryologic and etiologic aspects of the condition, with little emphasis on treatment, although Gussenbauer⁵ recommended excision by thermocautery as early as 1893.

All commentators with the exception of one early writer (who considered them due to ingrowing hairs) agree that the conditions are of congenital origin. The theories, however, vary widely as to the particular embryonal layer from which they arise, as well as their mode of origin. Walker²⁵ believed his case to be a "monstrosity by inclusion." Feré²⁶ and Bland Sutton⁶ regarded sinuses and cysts as "slight defects in the coalescence of the superficial portions of the medullary folds in the sacrococcygeal region." Terrillon⁷ stated they were a special form of spina bifida involving the skin. Lawson Tait⁸ suggested that the coccygeal dimple is the "cicatrix of the spina bifida by which the human tail has been lost." Lannelongue^{9, 10} suggested the following interesting theory: "The mesoblast lies, after the formation of the medullary canal, between the external epidermis and the vertebral column, except in the region of the sacrum, where little of this tissue is interposed, so that this region is reduced to epidermis and bone. Consequently, the superficial layer, the epiblast, joined at a later period to the mesoblast, preserves closer relation with the bone, and later, when the subcutaneous tissue is developed around these places a depression will be formed. If deep and narrow enough, the orifice may close up and a dermoid cyst will be the consequence." Tourneaux and Hermann,¹¹ who worked with the greatest amount of material, concluded that the sinuses and cysts were remnants of the conflict for survival

of the medullary tube as encroached on by the last portions of the spine to close, believing they were epidermis invaginated by the pull of the filum terminale. The foveola coccygea (or fossette medullaires) *i.e.*, the English "dimple," they attributed to the inturning of the coccyx. They could find no evidence of contact with the postanal gut.

Mallory¹² in America, after dissection of six fetuses, confirmed the work of Tourneaux and Hermann¹¹ as to remnants of the medullary canal, and believed these capable of giving rise to the picture seen in congenital sinuses and cysts. He stated that in all probability it is only these congenital sinuses and cysts that give rise to suppurative sinuses. Most French and German authors lean to the views developed by Lannelongue.⁹ Aschoff¹³ also threw the weight of his authority to the view that sinuses and cysts are due to faulty *median skin agglutination of the sacrococcygeal region, although he agreed with Tourneaux and Hermann¹¹ that the foveola coccygea are due to antero-flexion of the coccyx in which the remaining strands of the medullary tube act as tractors on the skin. Nassè¹⁴ mentions the neurenteric canal as a possible origin, and thinks all cysts can be explained as arising from this or the medullary canal. Klemm,¹⁵ while attributing the cysts to faulty skin development, believed that after invagination, growth of the invaginated skin occurs to produce the multiple sinuses.*

Masson¹⁶ quotes Ewing as stating that the embryonal structure which gives rise to all growths in this region are chiefly: (1) Fovea coccygeal and coccygeal vestiges of the neural canal. (2) Neurenteric canal. (3) Postanal gut. (4) Proctodeal membrane. To these must be added the epithelium of the sacrococcygeal region. All commentators agree, however, that the cysts, sinuses and dimples of the sacrococcygeal region arise from one primitive layer only.

Against the theory of inclusion bodies are the facts: (1) That hair and squamous epithelium only of the possible teratoid structures are found constantly in these conditions. (2) The structures present are fully differentiated. (3) Malignant change has never been described as occurring in a definite pilonidal cyst.

Between the structures under discussion and the various tumors of this region there are in the case of the first only true skin formations, whereas in the latter all types of epithelial structures are found as well as connective and nervous tissue. If we are to assume that the neurenteric canal or neural groove or medullary canal have anything to do with the formation of cysts or sinuses, we must explain why only true skin tissues are ever found in these latter structures. One would certainly expect to find some transition from columnar to squamous epithelium. One has also to explain why nerve tissue is notably absent in cysts. The rôle of the vestigial structures in the formation of tumors of the sacrococcygeal region is undeniable. They probably never play a rôle in the formation of cysts or sinuses. The dimple may possibly be due to the traction caused by the inturning of the coccyx.

We are led, therefore, to feel that these cysts and sinuses are purely and solely derived from faulty agglutination of fetal skin folds. The presence of similar lesions in other parts of the body in the midline are confirmatory inferentially. Clinically this is confirmed by the findings at operation. It has been found that the sinuses and cysts are in the skin and subcutaneous tissue and invariably are bounded by the deep fascia covering the dorsum of the sacrum and coccyx. In our series it has never been found necessary to incise this covering in order to completely excise these lesions.

In those cases where multiple sinuses are found they are probably due to infection resulting in multiple pointing and rupturing and are as a general rule lined by granulation tissue. Certain cases, however, are said to show multiple epithelium-lined sinuses and if these exist, we must fall back to the theory of Klemm¹⁵ for the explanation. If our explanation is to be accepted

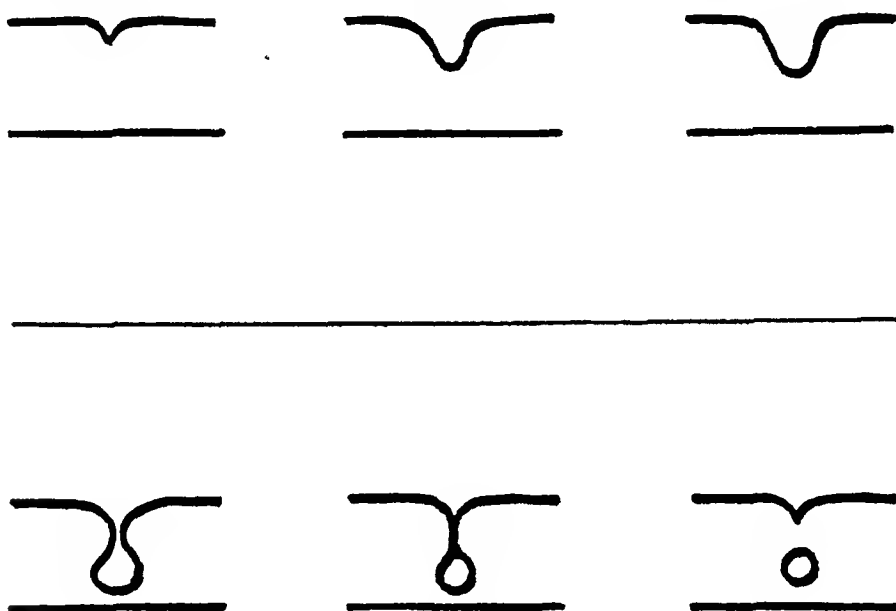


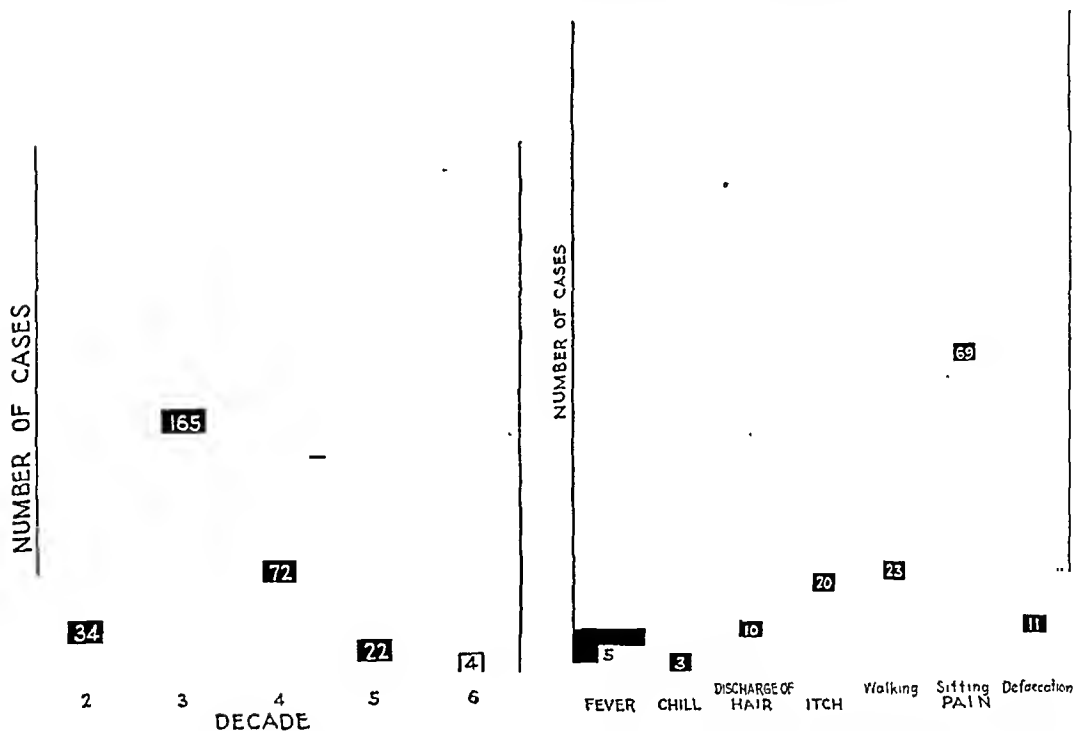
FIG. 1.—Illustrating the formation of the variations found
(from Markoe and Schley).

the following simple diagrams taken from Markoe and Schley² adequately illustrate the formation of the variations found (Fig. 1).

The true microscopic pathology of these conditions is probably rarely seen. The sections of these cases showed no case of simple uninfamed tissue. The predominant picture was acute and chronic inflammation. The peculiarities were numerous foreign body giant cells, and hair for which we could find no hair follicles. No sweat or sebaceous glands were found in the interiors of the cysts and sinuses, which could definitely be said to be connected with them or part of these congenital conditions. So far as our examinations of this large collection of material are concerned, the origin of the hair found in these conditions remains unexplained. Small islands of squamous cells were occasionally found either free or doubtfully attached to the cyst linings. Squamous epithelium containing the normal structures was found dipping into the sinuses at their entrances, but this epithelium became continuous at once with the inflammatory cyst or sinus lining. Harvey Stone¹⁷ had one

clear cut specimen in 61 cases. He notes only: "In a short sinus is a slightly modified invagination of true skin. None of its elements is fully developed."

In the earlier literature Gussenbauer,⁵ Crone,¹⁸ describe the presence of squamous epithelium, hair follicles, sebaceous and sweat glands. As neither of them had many cases (Crone¹⁸ had only six), it is curious that they should have seen these things. The origin of the conception that these things are present in sacrococcygeal cysts probably can be traced to these writers. They are not described by pathologists or commentators on much larger series. The most careful microscopic studies made, those of Oehlecker,¹⁹ including serial sections, showed no characteristic epithelial structures.



GRAPH 1.—Showing age groupings of patients on admission.

GRAPH 2.—Showing incidence of the various symptoms on admission.

Incidence.—Winkler²⁰ found 30 cases in 19,000 hospital admissions or 1:600. Wette²¹ found seven cases in 15,000 hospital admissions or 1:2,143. Our 288 cases were found in 481,384 hospital admissions or 1:1,683.

Race.—Thomason²² in Texas (1934), and Stone¹⁷ in Maryland (1924) found no colored patients in their series. Our series shows one female and three male colored patients.

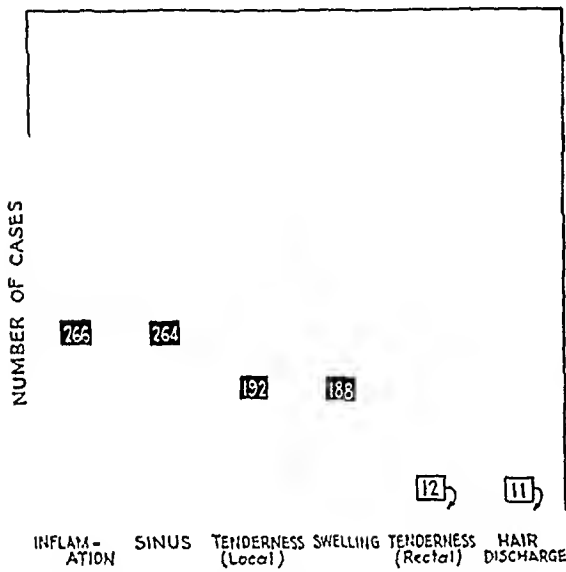
Age.—Depres²³ and Lannelongue⁹ state that congenital sacrococcygeal cysts occur in one-third of all new born in some degree, but only 3 per cent of adults show it. Tait⁸ stated that they occurred in 23 per cent of all women examined. Over one-half of the cases come for treatment in the third decade, and one-fourth in the fourth decade (Graph 1).

Sex.—In this series 241 were males and 47 females. One might expect this to have some bearing on the question of trauma. Of the 39 cases who

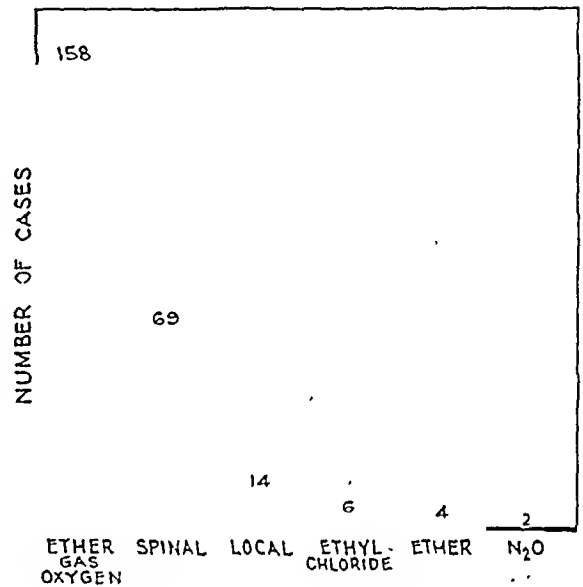
gave histories of trauma, 27 were males, 12 females, the time varying from one week to eight years, the greater number being within one month. They consisted of blows, falls, jolting of cars, etc.

Hereditary Factors.—There was no evidence of any familial disposition to these abnormalities, only five cases having a family history of pilonidal cysts and sinuses. Congenital malformation other than sacrococcygeal sinuses and cysts were present in only one case—club feet. Syphilis and tuberculosis: We found no cases of tuberculosis and curiously enough of 123 Wassermanns taken, only seven were positive, a slightly lower incidence than usual for this age grouping.

Symptomatology.—Itching, pain on sitting or walking and the discharge of pus were the predominant symptoms. One child of four had a tumor



GRAPH 3.—Showing incidence of the various physical signs on admission.



GRAPH 4.—Showing types of anesthesia used.

above the anus since birth. The average time of symptoms before admission was 795 days. The shortest period was three days, the longest 8,760 days. Seventy-six cases had symptoms for a period of three years or over (Graph 2).

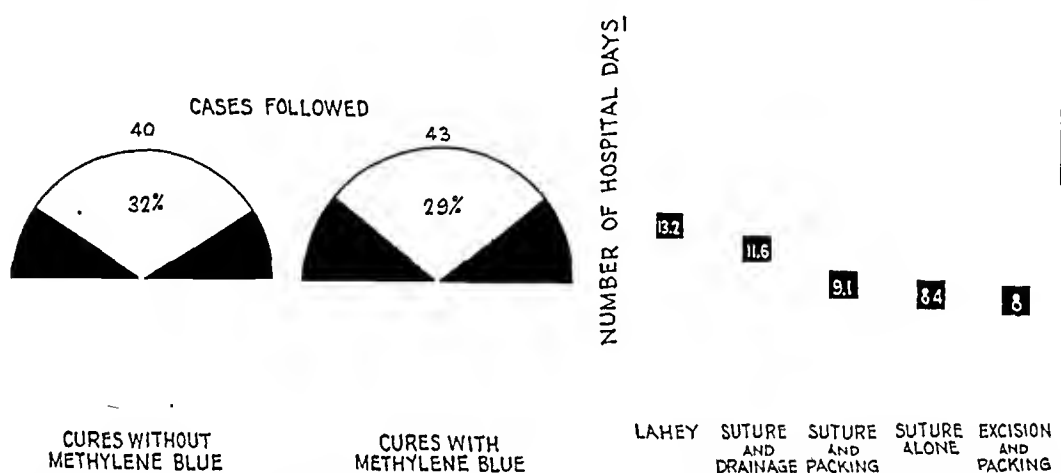
Physical Examination.—All cases in this series showed evidence of inflammation upon admission. It would seem that the simple presence of these abnormalities caused no symptoms important enough to bring the patient to the doctor (Graph 3).

Differential Diagnosis.—Occasionally the following conditions may be considered: Simple acute suppurative inflammation (furuncle), sebaceous cysts, lipomata, fibromata, tuberculosis, chancroid, fungous infections, malignant ulcer, inflammation of congenital tumor, syphilis and anthrax.

Anesthesia.—In this group, it is noteworthy that only 14 local, and no caudal anesthetics were employed probably because of the juxtaposition of the inflammatory area. Sixty-nine spinal anesthetics were used, probably partially, due to the fact that the renewal of favor to this type of anesthetic

reached its height in the period covered by our series. We feel definitely that the possibility of introducing organisms by spinal puncture, in the presence of an inflammatory lesion of the back, is very great. Gas, oxygen and ether was used in the greater number of cases and would seem to be the method of choice. (Graph 4).

Treatment.—There is unanimity of opinion as to the necessity for complete surgical excision of sacrococcygeal cysts and sinuses for the cure of these conditions. One hundred and six of our cases had one or more previous incisions and drainages. Twenty-nine cases had had previous excision. The method of insuring complete excision and the after treatment of the wounds has been a matter of great debate. The use of a delineating reagent such as methylene blue for outlining the ramifications of the sinuses would seem to be a helpful measure in the excisions. Actually our percentages of



GRAPH 5.—Showing comparative results with or without methylene blue as delineating reagent.

GRAPH 6.—Showing average stay in the hospital postoperatively for all methods of extirpation.

recurrence are the same with or without such a reagent (Graph 5). We have not used roentgen ray or opaque media injections in our series.

Follow Up.—We have been able to follow 83 cases of our series of 288, a rather remarkable percentage of follow up for such a condition, in a general hospital (such as Bellevue) with a large floating population. The follow ups vary from two to 14 months. The methods of extirpation and closure used with their end-results, including the number of postoperative hospital days are shown in Table I. The total cures for the series were 73 per cent for all excisions. Excision and packing show 30 cures for 32 cases. Excision and suture (including plastic procedures) without drainage show 56 per cent cures; excision, suture and packing show 63 per cent cures; excision, suture and drainage show 66 per cent cures, an average of 62 per cent cures for 50 cases in which sutures were used. There was one cure by incision and drainage alone in this series. The postoperative hospitalization for all methods is shown in Graph 6. There were no deaths. There was one case of severe bleeding postoperatively, which, however, did not need transfusion, and one case developed erysipelas. There were five late

complications. One had marked tenderness still at the end of eight months. Two complained of pain about the scar. One note was made of adhesion to the sacrum, and one case formed crusts and failed to epithelialize satisfactorily.

Discussion.—Since all these cases are infected on admission to the hospital and the wounds are in close proximity to the rectum, we have seen practically 100 per cent infection in our follow up observations present during the convalescence in every method used. Thus any method involving closure of the wounds would on general surgical principles seem to be contra-indicated. The tendency to widespread infection is undoubtedly lessened by preliminary incision and drainage of abscesses prior to excision if one be present. The

TABLE I.
Showing End Results for the Various Types of Operation

TYPE OF OPERATION	TOTAL NUMBER OF CASES	NUMBER OF CASES FOLLOWED	NUMBER OF CURES	PERCENT OF CURES
Excision & Packing	132	32	30	94
Excision, Suture & Packing	79	24	15	63
Excision & Suture	29	18	10	56
Excision, Suture & Drainage	27	9	6	66
Incision & Drainage	21	16	1	7
All Types (totals)	288	99	62	63
Corrected For I. & D.	267	83	61	73

probability is that infection will be a less prominent factor if the excisions are really radical. The tendency to try to conserve tissue cannot be considered in the removal of pilonidal cysts and sinuses. The necessity for dressings from six weeks to three months should be understood by the patient from the beginning and this period in our experience has not been shortened by any method of suture attempted, including that of Lahey, in which drainage from the lower angle of the wound has lasted regularly six to eight weeks. The Lahey²⁴ operation differs from other methods of suturing in that it displaces the scar lateral to the midline, in order to prevent tenderness and pain on sitting. Only three of our cases with midline scars complained of pain over the scar, obviously not enough to warrant the opening of a new area to infection.

We have emphasized the almost universal presence of infection. This is minimized to a great extent by meticulous care and frequent dressings. In the majority of our cases iodoform gauze packing was used as a deodorant,

but antiseptics in general, dichloramine T, potassium permanganate, mercuriochrome, *etc.*, have been used only for the first few days. We have not noted any superiority of antiseptics to packing alone.

The dressing is important. It should prevent the seepage of exudate over the anal region and perineum. It should remain in place during defecation, sleep and walking. The following has been found most practical. The patient is dressed in the erect position. The wound is washed with tincture of green soap and peroxide. The wound is packed lightly with a large gauze fluff to completely fill the cavity. A marine or rubber bath sponge about an inch thick and somewhat larger than the wound is placed over the gauze and cut off squarely at the internatal cleft about an inch above the anus. A two-inch "dryback" adhesive plaster strip is applied tightly across the inferior border of the sponge and carried around to below the anterior superior spines of the ilia. A similar strip is applied at the upper border. The wound is dressed about every fourth day.

CONCLUSIONS

(1) A ten year survey of 288 cases of pilonidal cysts and sinuses from the Surgical Services of Bellevue Hospital, New York City, has been reported, including the follow up of 83 cases.

(2) These congenital malformations originate from faulty skin development.

(3) Trauma is not ordinarily a factor in the onset of symptoms.

(4) The predominant symptoms are due to infection.

(5) The pathologic picture is that of acute and chronic inflammation of skin.

(6) Spinal, caudal, and local anesthetics are definitely contraindicated.

(7) Delineating reagents in the operation have not reduced the incidence of recurrence.

(8) Complete excision and packing is the method of choice.

(9) A method of dressing is suggested.

NOTE.—We wish to express our appreciation to Dr. Arthur M. Wright, Dr. Guilford S. Dudley and Dr. John A. McCreery for their courtesy in allowing us to use the cases from their respective services at Bellevue Hospital; and to Dr. Douglas Symmers, of the Department of Pathology, for permission to examine the microscopic sections from these cases.

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BRIEF COMMUNICATIONS AND CASE REPORTS

AMPUTATION FOLLOWING "PAVAEX" TREATMENT

REPORT OF A CASE

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THAT the method of treating vascular diseases of the extremities by means of the passive vascular exerciser ("Pavaex") as suggested by Reid and Hermann may not be entirely devoid of danger is exemplified by the following case:

CASE REPORT

Mrs. A. A., aged 61, had a midhigh amputation of the right leg at the Johns Hopkins Hospital in 1933 because of gangrene. The diagnosis was arteriosclerosis. Patient had suffered from hypertension for many years.

In August, 1934, her left foot began to hurt and she was admitted to the West Baltimore General Hospital where the intravenous salt solution treatment was given. When this failed to give relief she was referred to another hospital for the "Pavaex" treatment and it was following this that she began to have pain, redness and swelling on the inner side of the leg between the knee and the ankle. She says she called the attention of the doctor in charge to this condition but he said it was of no consequence and continued the treatment. When the leg became still more painful she gave up the treatment of her own accord.

On October 23, 1934, the patient first came under my care. At that time the left foot was a little cool and slightly edematous but there were no ulcers present. There were a number of enlarged superficial veins over the ankle and inner side of the foot. Running up along the inner side of the leg, however, there was a very definite and extensive area of cellulitis along the course of the internal saphenous vein—which was thrombosed—extending practically from the ankle to the knee. This area was red, inflamed, and definitely sensitive. Patient complained it was so painful she could not sleep at night. There were two small dry black patches of skin necrosis in the center of this inflammatory area about one inch apart, one about the size of the end of one's finger and the other about half as large. No arterial pulsations were to be felt in the leg—not even in the femoral at the groin. Blood pressure 210/110. Diagnosis: obliterating endarteritis.

Patient was admitted to the Hospital for the Women of Maryland where, with rest in bed and continuous warm, wet compresses, the condition began to improve and for a time it looked as if it might resolve itself. After several weeks the process became stationary and then slowly but surely began to get worse. The patient was restless at the hospital and was sent home for a while, following which she was persuaded to go into the West Baltimore General Hospital. The two little areas of skin necrosis began to get larger and became definitely ulcerated. The cellulitis, too, began to spread and the patient ran an irregular temperature. All this time her foot remained free from gangrene or ulcer, although it did become slightly more edematous.

The patient insisted on going home. She was there but a short time when the big toe became dark and later on definitely gangrenous. Furthermore, she was suffering considerable pain and a chronic bronchitis was becoming definitely worse. The subject of amputation had been considered some weeks previously but the patient's family would not consent to it. Finally it became obvious that life could be saved only by amputation. She was sent into the Sinai Hospital, where, under evipan anesthesia, a midhigh amputation was done. No tourniquet was used and outside of the great vessels hardly a ligature had to be applied. Her convalescence was uneventful.

This case is reported because such occurrences as this should be brought to the attention of the profession. I personally feel that the "Pavaex" machine is a distinct advance in the treatment of vascular diseases of the extremities, but it is a new departure and the bad as well as the good must be known and recognized in order to evaluate its proper place in our armamentarium. It may very well be that the "Pavaex" treatment in the above-mentioned case had nothing to do with the result; possibly it was purely a coincidence that this patient developed a cellulitis following its use. The probabilities, however, are that this was not the case, and certainly the operator of the machine should have stopped using it on this patient when his attention was called to the obviously increasing cellulitis.

It would seem that not all vascular diseases are suitable for this treatment and that until its limitations are known one should use great care and discrimination in the selection of cases for its use. It would further seem that any cellulitis or phlebitis of an acute nature is a contra-indication, in the first place, and if it occurs during the treatment it should serve as a warning that the treatment had best be discontinued, at least for the time being.

NONTRAUMATIC HERNIA THROUGH THE RIGHT PARASTERNAL FORAMEN OF MORGAGNI*

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AND

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HERNIATIONS through various parts of the diaphragm have been reported in such increasing numbers in recent years that the addition of a single case report would seem to have no justification. However, the present case offered such difficulty in diagnosis that it warrants record.

CASE REPORT

The patient, a widow of 57, was admitted to the Surgical Division "E" of the Hospital of the University of Pennsylvania July 21, 1933, complaining of indigestion. Seventeen months previously she had been operated upon for acute appendicitis and at that time it was learned that for many years she had had attacks of indigestion, characterized by a feeling of fulness in the epigastrium and gaseous eructations after meals.

* Read before the Philadelphia Academy of Surgery, November 5, 1934.



FIG. B.
located anteriorly just to the
right of the midline and in the costophrenic sulcus.



FIG. A.

FIGS. 1 A and B.—Anteroposterior and lateral radiograms of chest showing large circumscribed lesion in lower part of right chest, located anteriorly just to the right of the midline and in the costophrenic sulcus.

For seven months after her appendectomy she was in good health but then again began to experience increasing epigastric distress. She took soda in large amounts with variable relief, and she was so uncomfortable after eating that she would frequently skip a meal. For three months before her admission in July she had frequent attacks of pain in the right upper quadrant of her abdomen which would radiate to her back and the top of her shoulder. This pain was nagging in character and there was tenderness of the painful area. The pain was more intense at night. Tomatoes and starchy foods always caused indigestion.

Examination on admission showed an obese white woman who was in no apparent distress and did not look sick. There was tenderness under the right twelfth rib and in the left hypochondrium. No masses and no organs were felt. Except for varicosities of both legs there were no other abnormal findings. Laboratory studies were all negative for any disease of the biliary or gastro-intestinal tracts. Van den Bergh reaction of the serum showed a negative direct reaction and the indirect showed 0.2 units of bilirubin; ieterus index was 5; duodenal drainage gave a good B fraction and the microscopic examination was negative. The cholecystogram was interpreted as showing no disturbance of gallbladder function. Blood Wassermann was negative. Hemoglobin, 87 per cent; white blood cells, 7,400; and blood urea nitrogen 22 milligrams per 100 cubic centimeters. Urine showed occasional leukocytes on microscopic examination. The gastro-intestinal radiographic studies revealed no evidence of disease of this tract but there was observed a large lesion in the right lower chest. Radiograms (Figs. 1A and B) were then taken and reported as follows: "There is a circumscribed lesion located anteriorly just to the right of the midline and in the costophrenic sulcus which does not appear to be inflammatory, does not restrict the movement of the chest walls or the domes of the diaphragm. It may be due to a primary tumor or an echinococcus cyst." At the 24-hour examination it was noted that there was no connection between the colon and the mass of the right half of the diaphragm. At her request she was discharged from the hospital to return at a later date for operation.

The patient was readmitted September 19, 1933. She had not had as severe pain in the upper abdomen but had experienced pain in the right lower back and had had severe headaches. Examination at this time showed her blood pressure to be 90/80, heart sounds faint. Deep pressure in the epigastrium and under the right costal margin elicited pain in the right back just to the right of the twelfth thoracic vertebra. Bronchoscopy showed deformity of the right stem and lower lobe bronchus which was thought to be due to extrabronchial causes. With the thought that the lesion might be due to an echinococcus cyst a complement fixation test for this disease was done with negative results. Blood studies were again normal. Following the induction of an artificial pneumothorax for diagnostic purposes roentgenograms of the chest with the patient erect and with her lying on her left side were made (Fig. 2). Two distinct shadows were seen at the right base. One presented a stringy appearance and corresponded to the fissure between the right middle and lower lobes. It was thought to be due to pleural thickening the result of an old inflammatory process. The lower and larger shadow appeared to be in the partially collapsed lower lobe. The film taken with the patient lying on her left side showed a definite change in shape of the lesion of the right lower lobe and that it merged with the heart shadow. There was seen an irregularity in the outline of the dome of the right diaphragm which was thought to have the appearance of an individualization of the costal components of the diaphragm. The lung lesion was thought by the roentgenologist to be an atelectatic and cirrhotic process in the right lower lobe due to a long-standing bronchial occlusion which was probably of inflammatory origin. Because of these conclusions the patient was again allowed to go home.

Once more, however, she had numerous attacks of pain in her abdomen. Now they were sharp in character and radiated around the right costal margin and localized in the superior surface of the right shoulder. Heavy lifting brought on attacks but they

also occurred at night and she would be aroused from sleep. Deep breathing accentuated the pain. On November 11 she again entered the hospital. Examination showed slight tenderness on deep pressure in the right costovertebral angle. Pressure in the left upper and right lower quadrants caused pain in the tender right upper quadrant and radiation of the pain to the right shoulder. Due to the persistence of her symptoms and to the uncertainty of the lesion in her chest an exploratory thoracotomy was decided upon with the diagnosis of pulmonary cyst leading the list of probabilities. In preparation for the operation a partial pneumothorax was again established and the diaphragm was temporarily paralyzed by crushing the phrenic nerve and its accessories in the neck.

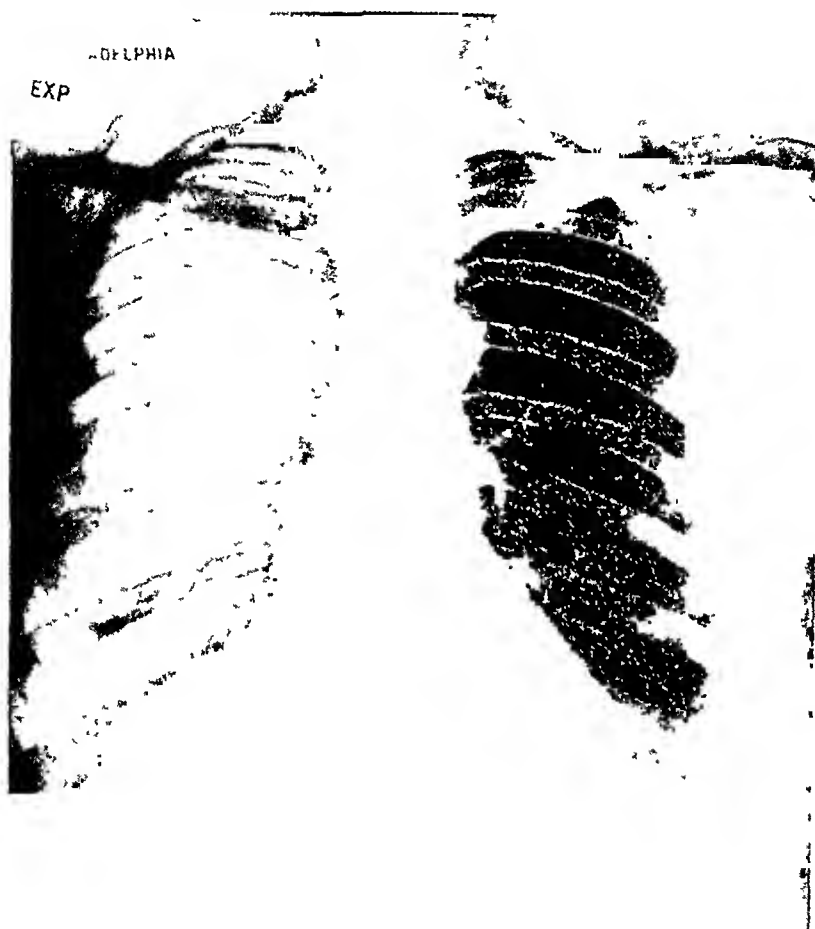


FIG. 2.—Anteroposterior radiogram of chest following partial pneumothorax. There is about 50 per cent collapse of the right lung. There are two distinct shadows seen at the right base. One of these presents a stringy appearance and in position corresponds to the interlobar fissure between the right middle and lower lobe. This shadow is evidently due to pleural thickening of inflammatory origin. The lower and larger shadow appears to be in the partially collapsed lower lobe.

Another roentgenogram (Figs. 3A and B) of the chest was reported by Doctor Pendergrass as follows: "In some respects the lesion has the appearance of a pleural tumor or a pleural cyst. Fluoroscopically the lesion does not move with respiration. We would advise a barium meal before any contemplated operative procedure to rule out the possibility of a right-sided hernia of the dome of the diaphragm." Examination after a barium meal was done with negative results. The surgical staff persisted in its diagnosis of pulmonary cyst.

Operation November 18, 1933, by Doctor Ravdin. Under local anesthesia with novocaine, supplemented with nitrous oxide-oxygen, an incision was made through the

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Figs. 3 A and B.—Anteroposterior and lateral views of chest following paralysis of right dome of the diaphragm and partial pneumothorax persists. Note the rounded shadow in anterior portion of chest, free from lung and apparently continuous with diaphragm. This was not reported by the roentgenologist.

FIG. A.

FIG. B.

There is elevation of right dome of the diaphragm. There is elevation of right dome of the diaphragm and apparently continuous with diaphragm. This was not reported by the roentgenologist.

fifth interspace from the posterior axillary line almost to the sternum. The fifth rib was divided at its osteochondral junction. A large fatty mass was seen in the region of the pericardium, from which it at first was thought to arise. After gentle blunt dissection this mass was removed. There was then seen a serous membrane-covered mass projecting upward through an oval defect in the diaphragm. The membrane was incised and omentum was encountered. On traction a portion of the transverse colon appeared. The omentum and colon were then returned to the peritoneal cavity. Upon separating the mass from the edges of the opening it was seen that the orifice measured about eight centimeters in length and three centimeters in width and started one centimeter from the anterior attachment of the diaphragm and extended posteriorly. This was, therefore, a hernia through the right foramen of Morgagni, the potential defect between the sternal and costal components of the diaphragm. After defining the edges, closure of the orifice was accomplished by means of an interrupted suture of doubled No. 1 chromic catgut. The pleural defect was then closed with a single continuous suture of the same material. Passivity of the diaphragm facilitated the repair. Pericostal sutures of doubled chromic catgut were then placed at intervals of two centimeters and the transected rib restored to its proper continuity by means of sutures passed through holes drilled in its ends. Before closing the muscle layers with catgut the lung was fully inflated. The skin and subcutaneous tissues were united with interrupted sutures of silkworm gut. Her condition during the operation was uniformly good and remained so at the close. For a few hours after the operation her blood pressure stayed at a low level but this was corrected by means of ephedrine and a transfusion of 125 cubic centimeters of citrated blood. Following this she made an uneventful convalescence. The wound healed by primary intention. There was a small pleural effusion for a few days. A roentgenogram of her chest on December 4 showed a disappearance of the original lesion, an elevated, paralyzed right half of the diaphragm and a very small pneumothorax. She was discharged in good condition on December 9, 1933.

Since then she had had no recurrence of her original symptoms and can now eat anything she desires without having indigestion. She had continued since operation to have twinges of pain which start in the region of her operative scar and radiate upward to her right shoulder. Radiographic examination on November 5, 1934, after a barium meal revealed return of function in the diaphragm and no evidence of her original lesion. The right half of the diaphragm is elevated and its range of motion is not as great as on the left but it is smooth in outline and moves normally.

This then is a case of nontraumatic hernia through the right parasternal foramen of Morgagni in which the symptoms and physical signs strongly suggested gallbladder disease. As the hernial sac contained only omentum no absolute evidence of the true condition could be obtained by roentgenologic studies. Although the correct diagnosis was suggested by one of the roentgenologists an exploratory thoracotomy was necessary to establish it and correct the condition found.

Herniations through the foramina of Morgagni are relatively rare. Hedblom,¹ in 1931, was able to find only 60 cases reported in the literature. He pointed out that as it was at times difficult to tell before operation whether the hernia originated on the right or left side and as these areas are accessible through an abdominal approach that this route should always be chosen.

Harrington,² Hedblom¹ and others³ have drawn attention to the frequency with which the symptoms of diaphragmatic hernia have been ascribed to disease of the gallbladder. In Harrington's 60 cases the preliminary diagnosis was cholecystitis in 29. Somewhat similar figures have been reported by other

observers. Next in frequency is the diagnosis of gastric disease and when one remembers the great preponderance of herniae through the esophageal hiatus and the high percentage of involvement of the stomach in the sac, such a mistake is readily understood. Irritation of the phrenic nerve endings must be a constant factor in these cases and undoubtedly accounts for many of the symptoms ascribed to disease of the gallbladder.

In our case the location and radiation of the pain clearly resulted from stimulation of the right phrenic nerve and probably of the intercostal nerves supplying sensory fibers to the periphery of the diaphragm.

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RUPTURE OF THE SIGMOID BY HYDROSTATIC PRESSURE*

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CASE REPORT.—A male, aged 60, was admitted to the service of Dr. Charles F. Mitchell, at the Pennsylvania Hospital, September 11, 1934. The patient had been constipated for a number of years and occasionally found it necessary to use enemata to promote evacuation. On the day of admission he had gone to the backyard to a water hydrant, of the type found in the backyards of Philadelphia in the poorer districts and to which was attached some three feet of rubber hose. A brass nozzle, such as is used in sprinkling a lawn, was attached to the free end. This was inserted into the rectum and the water turned on. He said that he felt the water running in and after a few seconds had a sharp agonizing pain in the lower abdomen. The nozzle was withdrawn, followed by the expulsion of a small amount of water and feces. He then made his way into the house and collapsed.

On admission the patient complained bitterly of pain in the abdomen which was more marked in the left lower quadrant. The rigidity was boardlike and generalized. There was no obliteration of liver dulness and there was no shifting dulness. There was no audible peristalsis. Temperature was 96.4°, pulse 80, respirations 30, white blood count 10,000, blood pressure 140/80. Rectal examination was negative. A diagnosis of rupture of the sigmoid was made. At operation five hours after the catastrophe the abdominal cavity was found to contain considerable fluid and particles of feces. About 500 cubic centimeters of fluid were aspirated. At the apex of the sigmoid flexure a tear about three centimeters long was found through the anterior longitudinal band. This was closed transversely with a double line of sutures. Two small tears in the serosa and muscularis with herniation of the mucosa were found proximal to this. These were also sutured. A rubber covered gauze drain was placed in the pelvis, and the abdomen closed around it. A tube was passed through the rectum so that its upper end was beyond the suture line. No evidence of disease of the remainder of the sigmoid was found. The postoperative course was uneventful. The rectal tube came out on the fourth day. There was drainage of colon bacillus pus from the wound for two weeks. The patient was discharged on the twenty-second day as well.

* Read before the Philadelphia Academy of Surgery, December 3, 1934.

This is the only case of its kind that the speaker has been able to find but probably this complication is much more frequent than is apparent. It seems unusual that with the frequent use of enemata and colonic irrigations, rupture of this organ appears to be so infrequent. The pressure of an ordinary enema is insufficient, but the pressure of colonic irrigations might conceivably produce rupture of the sigmoid.

It would seem that when the rectum is straightened out because of distention with fluid that the lower sigmoid would become kinked. This would cause a complete blockage at this point. Further distention would probably produce a rupture at the apex of the sigmoid. The same sequence of events would not take place if a gas such as air were used.

In 1911 E. Willys Andrews¹ published a report together with data concerning 11 cases of perforation of the sigmoid colon by air pressure. Burt² states that the rupture occurs generally along the longitudinal bands. In a series of experiments completed by him on the human intestine procured at autopsy he found that the sigmoid of a child withstood the greatest amount of pressure per square inch before rupture. This amounted to 11 pounds. Behrend and Hermann³ reported a case of what was thought to have been a perforation of the sigmoid as the result of a colonic irrigation given by a naturopath. They assumed that it was a perforation mainly because of the incised character of the wound in the wall of the intestine.

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DISCUSSION.—DR. WALTER E. LEE directed attention to the possibility of rupture of the rectum in proctoscopic examinations. Some years ago he had this occur during an examination, and knew of one other case which occurred several weeks before his own. He was using the old type of proctoscope with a sharp edge and the opening a long bevel. After removing the obturator and attempting to inflate with the hand bulb, with his left hand on the lower part of the abdominal wall, he felt the sensation of the air entering the peritoneal cavity. Pneumoperitoneum was demonstrated by roentgenography and within an hour the abdomen was opened and a small wound found in the anterior wall of the rectum about the junction of the rectum and sigmoid. This was closed by sutures, the abdomen closed without drainage, and the patient made an uneventful recovery. The other case to which he referred was not diagnosed until 72 hours after the accident and when the abdomen was opened there was a general peritonitis which proved fatal. At that time he made a search through the literature and could find no references to similar accidents, but they must have occurred, and the possibility should always be borne in mind.

DR. HARRY E. KNOX recalled the case of a man who was lying down outside a mill where he was employed near a compressed air hose and some of his fellow workers inserted a rubber hose in the rectum and turned on the compressed air. The patient came to postmortem several days later, at which time there were multiple lacerations in the rectum and sigmoid.

GUNSHOT WOUND OF THE HEAD AND OSTEOMYELITIS OF THE SKULL*

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CASE REPORTS

D. T., white male, aged 15, admitted to the Abington Hospital, April 2, 1933. While out shooting the previous week with an air rifle, he suddenly felt a sharp stabbing pain in his left temporoparietal region, and a drop of blood exuded. He suffered no inconvenience, failing to mention his injury to anyone. Forty-eight hours later a lump appeared, and a radiogram revealed a bullet just inside the bone.

Examination showed a small laceration in the left parietal region where the bullet had entered. This was scabbed over and apparently clean. Neurologic examination was essentially negative. Because of the absence of neurologic symptoms and because of the possibility that the laceration might be infected, it was decided to postpone removal of the bullet.

About 72 hours after his admission to the hospital he commenced to develop sensory aphasia and subsequently had a convulsion which commenced in his right hand and involved the entire right side. The aphasia became complete and a right hemiparesis, more marked in the hand and arm than in the leg, was noted. Inasmuch as he was developing signs of intracranial pressure, immediate operation seemed indicated.

A bone flap was made around the point at which the radiogram showed the bullet to lie. The bullet was found lying loose between the bone and the dura. The hole it had made in the bone was clean-cut and no bony spicules had been thrown off. The bullet fell out when the bone flap was reflected. It had expended its force in passing through the skin and the skull bones so that the dura had not been pierced. Four or five large hairs lay on the dura which was very tight and tense but not discolored.

Since the injury had occurred four or five days before, and since in spite of the presence of the hairs no infection had developed, opening of the dura seemed advisable, for no extradural pathology had been discovered to account for his symptoms. Wide reflection of this membrane revealed a tight brain. At about the center of the opening, there was a circumscribed area of contusion on the surface of the brain. On opening the pia at this point and nicking the cortex, an old, leathery mass of clot about six by three by three centimeters in size extruded. This left a cavity extending down into the brain to a depth of about six centimeters. Ragged brain tissue formed the walls of this cavity. With the suction apparatus all the damaged brain was removed and the opening was carefully extended into the ventricle. This was done so that the cavity formed by the clot might be filled by cerebrospinal fluid and thus prevent the formation of a serious scar. No bleeding accompanied this débridement of the brain. The dura was then tightly closed and the bone flap replaced. The skin was sutured in layers with stab wound drainage behind the posterior limb of the flap.

The boy made an uncomplicated recovery. Within 48 hours his speech was much improved and his hemiparesis disappearing. At the end of two weeks, his speech was normal and his right extremities had normal power. The only obvious sequela was complete astereognosis in his right hand and loss of position in the right big toe. Examination 18 months later revealed the boy to be normal in every respect.

OSTEOMYELITIS OF THE SKULL

M. D. W., white, female, aged 12, admitted to Graduate Hospital, January 5, 1934, with the chief complaint of swelling over the right forehead with chronic discharge from the frontal sinus and septic temperature.

Following swimming three months previously she had a frontal sinus infection

* Read before the Philadelphia Academy of Surgery, November 5, 1934.

which finally developed into pansinusitis. She then had a subperiosteal abscess in the midline about five centimeters above the eyebrow which was opened and drained. Subsequently, she developed another subperiosteal abscess about five centimeters behind this and about five centimeters from the midline on the left side. The drainage afforded was not adequate to take care of the situation.

Physical examination revealed a thin, pale child with a small incision just above the hairline in the midline in front from which pus was draining copiously. Neurologic examination was entirely negative. The eyegrounds were negative. Radiograms showed the presence of at least two sequestra with probable involvement of the left frontal bone in the osteomyelitic process. Operation seemed indicated to afford better drainage.

January 9, 1934, under local anesthesia, an incision was made in the midline of the forehead and carried upward about ten centimeters and then laterally to the left to include the left frontal bone and the infected area shown by the radiogram. There were two areas in which infection was most obvious; namely, directly in the midline about five centimeters above the left eyebrow and at about the frontotemporal suture about eight centimeters to the left of the midline. The skin flap was turned back and the periosteum stripped from the bone which seemed to be infected throughout. The sequestra was removed. Before we finished we had removed most of the left frontal bone piecemeal.

There were several extradural abscesses, particularly one that ran backward behind the sequestrum that lay on the left side at the frontotemporal suture. In pursuing the osteomyelitic process downward and forward, we were compelled to remove the roof of the left frontal sinus and establish drainage from this area into the nose. The condition was much more serious and widespread than the radiogram had indicated.

After the bone was removed, no attempt was made to remove the granulation tissue from the dura. The brain pulsated and there did not seem to be any evidence of an intradural collection. The wound was packed with gauze and the skin flap pulled back and secured in two places with silkworm gut sutures. Dakin irrigation was commenced.

Following this procedure, the child's condition improved somewhat. The temperature dropped and became more regular. The wound appeared to be clearing up well under the vigorous dakinization. However, on February 10, there was a change in her general condition. The discharge from the wound became very profuse and a soft swelling appeared to the right of the midline just in front of the temporoparietal suture. Roentgenologic examination at this time showed that the osteomyelitic condition was extending to involve the right frontal bone. Further operative intervention therefore seemed indicated.

February 24, 1934, under vinesthine anesthesia, the skin was stripped back from the bone in the right frontal region and a considerable area of bone in the right frontotemporal region removed. The two soft swellings were incised and the pus evacuated. Necrotic bone was found beneath each. This was widely removed. Our operative procedure on this occasion amounted to practically the same as it had on the other occasion except this time the bone was removed in the right frontal area rather than the left. Some bone was also taken from the left temporoparietal region. The child has very little left of her frontal bones on either side.

Following this procedure the condition improved. However, it was noted that the granulation tissue in the wound was extremely sluggish and of a peculiar grayish color. A blood count and hemoglobin estimation made March 1, 1934, showed that the child's hemoglobin was 28 per cent and the red cells 2,100,000. She was promptly given transfusions of 200 cubic centimeters of blood three times a week for the next six weeks. The effect of the transfusions on the granulation tissue and general condition of the wound was remarkable. After six transfusions her hemoglobin was 75 per cent and her red cell count 4,200,000. The granulation tissue now looked entirely normal; the discharge from the wound was much less; her temperature much more regular and her general condition and disposition much improved. By the end of March, the

osteomyelitis seemed definitely to be under control except for a small area in the right frontal region and a fairly well localized sequestrum in the left temporal region. The temperature was normal and the discharge from the wound much reduced.

On March 29, 1934, we were able to obtain a fairly satisfactory closure of the wound. The tips of these skin flaps were pierced with needles, the left frontal and the right parietal flap and the right frontal and the left parietal being pulled together by gentle traction from rubber bands over the needles. At this time also, two dozen small pinch grafts were placed at various points over the denuded area.

From this time on the wound healed slowly but satisfactorily. The child was discharged May 25, 1934, with the wound entirely dry. The cosmetic result was quite satisfactory, since we had carefully avoided any incision in the forehead below the hair-line except exactly in the midline. This area we had been able to improve by a plastic procedure at our third operation so that that scar was practically invisible.

The area from which the bone had been removed seemed to include the left frontal bone from a point about three centimeters in front of the vertex down to and including the top but not the anterior wall of the left frontal sinus and laterally into the left temporal fossa to a point about one and one-half centimeters above the zygoma. On the right side the right frontal bone was removed down to but not into the right frontal sinus and laterally only to a point about four centimeters above the zygoma and posteriorly up to the frontoparietal suture.

We preserved the child's hair, and at the present time she has a wig which fits over a flat aluminum plate giving protection against any possible unexpected injury to her head.

AN INCISION FOR THE EXPOSURE OF THE VENTRAL SURFACE OF THE DISTAL END OF THE RADIUS AND ITS RELATED STRUCTURES*

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FROM THE DANIEL BAUGH INSTITUTE OF ANATOMY OF THE JEFFERSON MEDICAL COLLEGE

THE incision here presented gives an excellent anatomic approach to the ventral (anterior) surface of the distal end of the radius and its related structures. It was first used for the open reduction of fractures of lower end of the radius with anterior or ventral displacement of the distal fragment or fragments.

Incision.—(Fig. 1) The pisiform bone is located and the surface topography of the flexor carpi ulnaris carefully outlined. The pisiform bone is easily palpated and is on a plane anterior to the other carpal bones. Having noted the above landmarks—the incision begins one centimeter radial or lateral to the pisiform bone and is carried proximally for a distance of five to six centimeters parallel to the flexor carpi ulnaris. Continuing the incision through the skin and subcutaneous tissues, the ulnar nerve and artery are exposed and together with the flexor carpi ulnaris are retracted medially or to the ulnar side. The entire group of flexor tendons are now retracted laterally or to the radial side. Careful snips with scissors or knife of the volar (anterior) radiocarpal ligament readily permits wide separation in the anatomic plane between flexor carpi ulnaris and the other flexor tendons.

* Read before the Philadelphia Academy of Surgery, December 3, 1934.

This approach injures no important nerves or vessels, and avoids opening the sheaths of any of the flexor tendons. Severing the medial segment of the volar radiocarpal ligament permits wide separation between the flexor carpi ulnaris and the other flexor tendons.

The medial segment of the volar (anterior) radiocarpal ligament is the weakest part of this ligament, and its incision in no way interferes with the integrity of the lateral (radial) segment which bears direct relation to the group of the flexor tendons, which are retracted laterally. The entire group of flexor tendons, with the exception of flexor carpi ulnaris, normally lie

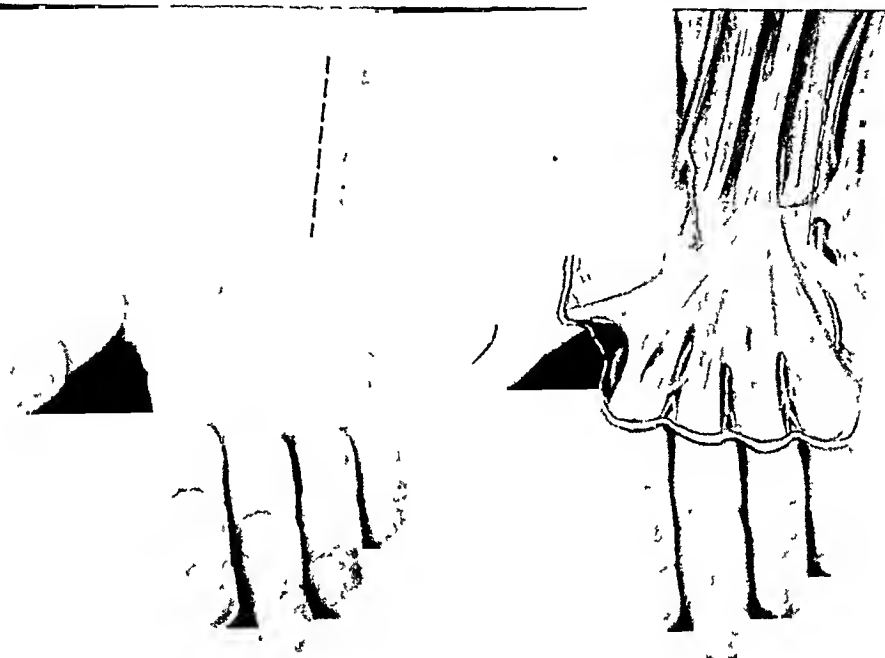


FIG. 1.—Showing site of incision and relation of anatomic structures exposed.

in the smooth depression or hollow formed by the ventral surface of the carpal bones.

Wiedhopf¹ describes an identical incision for the excision of the lunate bone. This approach to the lunate bone seems more direct and less traumatizing than the dorsal approach or the other types of volar incisions that have been used. The difficulty of excision of the lunate through the dorsal route has been noted by a number of surgeons. Orientation from the dorsal aspect is not easy. Cases have been reported in which the triquetrum (cuneiform) or navicular with or without the lunate have been removed in mistake for the lunate. Tillman has advised the insertion of a needle in the lunate bone to aid in its recognition, previous to removal.

The lunate lies obliquely in an upward and inward direction, and by placing the wrist in maximum radial abduction and dorsiflexion with the fingers flexed, the lunate bone is made more prominent and accessible. The anterior surface of the lunate is larger than the dorsal surface, and has only weak ligamentous bands; the dorsal surface is rough and ligamentous. The volar incision allows complete orientation before the radiocarpal joint is opened. And the smooth ventral surface of the distal end of the radius per-

mits easy lateral or radial retraction of the flexor tendons. Once the radio-carpal articulation is opened, the lunate is readily removed.

This incision permits an excellent exposure of the inferior radio-ulnar articulation. The importance of the functional integrity of the inferior radio-ulnar articulation in certain types of ankylosis of the wrist, either of infectious or traumatic origin, is often overlooked. When the elbow is extended, rotation of the forearm is possible by means of rotation at the shoulder joint. With the elbow flexed, rotation (supination and pronation) of the forearm takes place about an axis formed by the ulna and the fifth metacarpal. This rotary movement of the radius about the ulna takes place in the superior and inferior radio-ulnar articulations.

The radius and the hand rotate about this axis as a unit. And at the inferior radio-ulnar articulation the radius and the hand swing about the head of the ulna, much like a door on a hinge. It is a matter of common knowledge that if ankylosis of the wrist is associated with (1) good position of the carpal bones; (2) no loss of pronation and supination; (3) free flexion and extension of the fingers, there is little disturbance in function and such an individual has a good useful hand.

Ankylosis of the radiocarpal articulation showing no involvement of the inferior radio-ulnar articulation does not result in a loss of pronation and supination, since the radius and carpal bones rotate as a single unit. On the other hand, if involvement of the inferior radio-ulnar articulation develops in addition to the ankylosis of the wrist, the resultant loss of pronation and supination produces considerable crippling in the function of the hand.

The type of ankylosis of the wrist that is associated with a loss of supination and pronation, for which no cause other than involvement of the inferior radio-ulnar articulation is found, pronation and supination may be re-established, either by an arthroplasty of this articulation or artificial pseudarthrosis proximal to the head of the ulna, or by a subperiosteal resection of the ulna (head and neck) leaving the styloid process intact (Darrach's operation).

REFERENCE

¹ Wiedhopf, O.: Deut. Ztschr. f. Chir., vol. 235, p. 384, 1932.

DISCUSSION.—DR. B. FRANKLIN BUZBY said that personally, he had had no experience with this incision. There were three or four points which Doctor Lipshutz had brought out with which he was not in accord. First, concerning the excision of the semilunar bone. There are three indications for this: the first is dislocation, the second Kienboch's disease and the third fractures. In Kienboch's disease when dealing with the soft bone we should make a dorsal incision as is commonly done between the extensors of the fingers, outline the semilunar bone and cut its stronger ligamentous attachments on the dorsum from the weaker ligament on the flexor surface and deliver the bone intact without fragmentation, thereby doing less damage to the wrist joint as a whole. When dealing with dislocations of the semilunar the median nerve is frequently damaged. Through the incision as described by Doctor Lipshutz it cannot be exposed. In that case the flexor

midline incision would be the better. The mistake to which he refers, namely that the cuneiform and the semilunar are sometimes removed in place of each other, it would seem that if the incision is properly placed dorsally this mistake is not so apt to happen. I could not quite understand his description as to the use of this incision in removal of a segment of the lower ulna to permit pronation and supination of the forearm in low radio-ulnar synostosis. It seems to me that if we want to take a section out of the lower ulna it is going quite a bit afield to approach it through Dr. Lipshutz's incision when it can be approached safely by an incision directly over the bony operative site itself with easy retraction of contiguous structures. For fractures of the lower end of the radius with anterior displacement it seems the ideal procedure. For other fractures of the lower end of the radius it would seem too far to the ulnar side.

ANTERIOR PERINEPHRITIC ABSCESS*

ABDOMINAL AND THORACIC COMPLICATIONS

CONDUCT W. CUTLER, JR., M.D.

NEW YORK, N.Y.

CASE REPORT.—A man, 21 years old, was admitted to Roosevelt Hospital complaining of pain in the right lower abdomen of seven days' duration. He had been awakened at night on the date of onset with a sharp, stabbing pain in the right lower abdominal quadrant which radiated slightly to the back in the right lumbar region. No nausea or vomiting. The pain lasted a few minutes and disappeared, only to recur two days later. His only complaint on admission was of soreness in the right lower abdomen and the right flank which had persisted since the onset of his illness.

Examination showed no abnormalities except some muscular spasm in the right side of the abdomen. There was some tenderness at McBurney's point and also at the costal margin and extending into the right epigastrium. Slight costovertebral tenderness was noted on the right side.

On admission September 29, 1933, his temperature was 104.2° which, on the day following, subsided rather rapidly to normal. Blood count, 20,000; polymorphonuclears, 91 per cent. Urine showed an occasional white blood cell, rare red cell and repeated examinations the first few days following his admission showed no change in this respect until the third day when the number of white cells was somewhat increased. Notwithstanding his normal temperature, his blood count during the first few days continued high.

He continued to complain of the pain in the right upper quadrant which on the fourth day became much more severe and constant. He vomited several times a thin, yellowish material. There was, at this time, some diminution of breath sounds on the right side of the chest but no râles or friction rubs. The upper rectus was spastic and the maximum tenderness was discovered in the gallbladder area. It was thought that he was suffering from gallbladder colic although right pleurisy or possibly a kidney condition could not be excluded.

The gallbladder could not be visualized on roentgenographic examination. Cystoscopic examination showed nothing abnormal and a pyelogram was normal.

Operation through a right rectus incision on October 7. No abnormality was found in the stomach, gallbladder, duodenum, appendix or liver. An induration was felt near the posterior inferior margin of the liver and here the finger suddenly broke into a large abscess cavity lying between the kidney and liver extending up some distance beneath the ribs. A stab wound was made opposite the end of the eleventh rib in the flank and a tube placed directly into the abscess cavity. Another tube was brought out from the subhepatic area in the anterior abdominal wall which was closed above it.

* Presented before the New York Surgical Society, January 23, 1935.

ANTERIOR PERINEPHRITIC ABSCESS

The patient's temperature rose shortly after operation to 105°, gradually diminishing during the next ten days to 102½° at night and 100° in the morning. During this time the patient appeared quite septic and received numerous infusions and transfusions. The drainage from the anterior wound rather rapidly diminished and the tube was withdrawn. From the posterior wound the drainage was massive, containing large flocculi as well as pus and it was felt that some necrosis of the adjacent liver tissue was occurring. Blood culture was sterile. The signs in the right chest continued to suggest right lower lobe infiltration and the presence of some fluid. Roentgen examination of the chest suggested pneumonic lesion of the right lung with pleural fluid. A thoracentesis on his twelfth postoperative day showed no pus. On the sixteenth postoperative day a roentgenogram showed increased amount of fluid in the pleural cavity with displacement of the heart to the left side. The patient's temperature had begun to rise again reaching 105°. Another thoracentesis was done and about ten cubic centimetres of foul smelling, creamy pus was obtained. A later puncture obtained only clear fluid. The original stab wound was enlarged and the finger introduced into the abscess cavity. This contained a large quantity of thick pus, and it was felt that the exploratory puncture of the day before had probably entered this cavity rather than the pleural space.

The temperature ranged to 103° for five days then rose to 105° during the next two days. Thoracentesis in the fifth interspace posteriorly obtained 900 cubic centimetres of thin, slightly cloudy fluid. Culture from this was negative. The patient seemed much improved by this measure and continued for a week with temperature running only to 102°. Roentgen ray now showed some elevation of the right leaf of the diaphragm, and it was felt that there might have been some extension from the abscess into the subdiaphragmatic area. As the patient's condition continued to improve no further intervention was undertaken. Lipiodol injection of the sinus tract leading to the abscess showed no communication above the diaphragm.

An exploratory puncture of the chest was again done December 4, in the seventh interspace in the anterior axillary line and about 40 cubic centimetres of thick, creamy pus was obtained. On December 8 an attempt was made to introduce a needle again into the pocket previously discovered, without success. The original drainage wound in the side was enlarged again and the finger introduced. No pus was encountered. Exploration beneath the diaphragm well up above the dome of the liver showed no pus in this area. A drain was introduced. Owing to the patient's condition, it was decided not to do a complete thoracotomy at this time but a segment of the rib was removed and the wound packed open.

The patient's condition continued to improve without further manipulation, the temperature reaching normal December 25: He was discharged January 18, 1934, 102 days after his first operation. His subsequent course has been entirely uneventful.

This case is shown to illustrate: (1) A difficulty in diagnosis which may arise in distinguishing between an anterior perinephritic abscess and certain abdominal conditions—notably retrocolic appendicitis, acute cholecystitis, and liver abscess. (2) Complications, abdominal and thoracic, that may result from such a condition.

DISCUSSION.—DR. A. HYMAN felt that the diagnosis of anterior perinephritic abscess was frequently overlooked, as illustrated in the case just presented which was mistaken for a gallbladder condition. When the abscess is on the anterior surface of the kidney, the renal symptoms may be negligible and the upper abdominal symptoms so pronounced as to closely simulate gallbladder pathology. The urologist sees these cases more frequently, and with refined methods of diagnosis is more apt to make a correct diagnosis.

He wished to know if the radiogram showed obliteration of the psoas muscle outline, or deviation of the spine. These two radiographic changes

are of considerable diagnostic import. Pyelography, either retrograde or intravenous, very often gives additional diagnostic data. The pyelogram may show only very slight changes, evidenced by compression or distortion, and unless properly interpreted may be overlooked.

The urinary and cystoscopic findings may be entirely normal, also kidney functional tests. An additional aid in diagnosis is the culture of the urine. Practically all of these cases are *Staphylococcus aureus* infections and a positive culture from the suspected kidney with negative findings from the other side is of diagnostic value.

He inquired whether the pulmonary complication was due to a perforation of the abscess through the diaphragm. Two years ago, Doctor Kingenstein showed a man of 62, who was operated upon for a left perinephric abscess secondary to a calculous pyonephrosis. Thirty-two days following operation, during the course of a routine irrigation of the lumbar sinus with acriflavine, the patient experienced a paroxysm of coughing and expectorated a large amount of yellow stained watery fluid. It was evident that the patient had a communication between the perinephric region and the bronchial system. This was confirmed by lipiodol injections. Following a secondary nephrectomy, the patient slowly recovered from his infection and the bronchial fistula apparently closed. This type of pulmonary complication due to a perforation is extremely rare, only three cases having been reported in the literature in the last thirty years.

DOCTOR CUTLER said that the roentgenograms did not clearly demonstrate psoas obliteration. They had reviewed the films subsequently with that in mind, but the psoas showed no more vaguely on one side than on the other. There was a slight deviation of the spine which was thought might be accounted for by some irregularity in the patient's position on the table, especially in view of an entirely normal pyelogram. There was *Staphylococcus aureus* in the pus obtained from the original abscess. In the urine, there was only a somewhat more than normal number of white cells and only a few red blood cells before operation. There was no pus until three days after operation. As to the extension into the chest, it was thought to be by contiguity rather than by anatomic extension. At one time in his prolonged septic chest complication the radiogram showed what purported to have been a small hydro- or pyopneumothorax. They had injected lipiodol through the drainage wound tract to see if there was extension into the pleural cavity, but no sinus was demonstrable.

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TRANSACTIONS OF THE AMERICAN SURGICAL ASSOCIATION

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ADDRESS OF THE PRESIDENT

HIGHER DEGREES IN THE PROFESSION OF SURGERY

EDWARD W. ARCHIBALD, M.D.

MONTREAL, CANADA

IN THESE latter days, and perhaps particularly in this new and progressive continent, there has arisen in considerable numbers a certain type of surgeon which we all recognize and deplore. He is the natural product of those discoveries and inventions—*anesthesia*, *asepsis*, fine tools, and well equipped small hospitals—which have rendered the practice of surgery, in its purely mechanical aspects, relatively safe. He is also the product of some of our national qualities, characteristic of all young and rapidly developing countries. He is progressive, venturesome, and self-confident, and such qualities are perhaps those which have placed the best of American surgery in its present proud position. But in the particular type to which I refer, venturesomeness becomes foolhardiness, and self-confidence is uncontrolled by knowledge. To such a man the sum of acquired knowledge is comprised in the popular theories of the year just past. Theory is counted as fact, and hypothesis as a thing proved. A decision to operate is based upon a medical catch word, or a rule of thumb. *Technic* becomes the be all and end all of surgery. Fingers replace brains, and handicraft outruns science. The result is that such a surgeon is apt to undertake operations which may be technically possible, but are scientifically unjustified. It is, our medical friends infer, an attitude of mind, which is the product of half-baked knowledge, which, in the last analysis, has in it more than a touch of carelessness, indeed, often towards the internist, a touch of impertinence. The medical man, interested and anxious, who finally decides

upon a surgical consultation, is often more in fear of the slipping mind than of the slipping hand.

While this type of surgeon is occasionally found, as we all know, on the staffs of even the largest of our hospitals, his special field lies in the small towns, and even in the country parts, and that field is an enormous one. And it has become obvious to intelligent and reflective surgeons that the most serious problem of the day is concerned with the provision of competent surgeons, not for the large metropolitan hospitals, which are naturally staffed by the best men, but for the small towns and rural districts, with their small local hospitals. Doctor Greenough called attention to this in his Inaugural Address at last year's Congress. It is extremely important, in view of the universal increase in the number and variety of surgical operations, popularized by the growing familiarity of the public with the idea, made relatively safe by asepsis and improved anesthesia, and rendered convenient by the rise of the small-town hospital all through the country, that there should be made available for this public a higher degree of surgical judgment and skill than has hitherto been the case. It is hardly necessary to say that these were in part the ideals of the Founders of the American College of Surgeons in 1913. But that there had grown up by that time, and that there still exists, a tendency on the part of imperfectly trained men to undertake major surgery, nobody will deny.

I submit that there is still a real need for the education of the surgically ambitious to a greater sense of personal responsibility, in fact of conscience, so that they will be unwilling to undertake the grave responsibilities of major surgery without adequate training. There is still much need of that adequate training on the part of many who wish to be recognized as surgeons. There is a need for the establishment of some sort of obligation, perhaps even a legal obligation, which would demand such adequate training. And there is also a definite need for the provision of greater facilities for the acquirement of that training. Moreover, the public should be enabled to recognize who is a responsible surgeon and who is not. That can be attained only by some degree or diploma, the holding of which would be a guarantee of such adequate training.

With these thoughts in mind, when I came to consider what should be the subject of this Presidential Address, it occurred to me that it might be interesting and perhaps useful to put before the members a short review of the conditions which, in various countries, have been laid down for the attainment of higher degrees in the profession of surgery.

We are all fairly well acquainted with the requirements of election to the Fellowship of the American College of Surgeons, which is practically the only certificate or diploma in America that can be acquired by one who may desire to practice surgery as a specialty. But we are, perhaps, less familiar with the details of the examinations leading to the Fellowship of the Royal College of Surgeons of England, of Edinburgh, of Australasia, or

of Canada; to the title of Chirurgien des Hôpitaux and of Agrégé, in France, and to the rank of Privat Dozent in Germany.

Let us take first England, including Scotland. What here constitutes the higher training in surgery, and what are the certificates of such training? Some of the larger universities offer a higher degree, usually called Master of Surgery; and I am told that to become a Master of Surgery at Cambridge, for instance, demands the passing of the stiffest examination in the world. But such degrees are purely academic, and candidates are few. When we think of the higher British surgery, we really consider only the Fellowship of the Royal College of Surgeons of England, of Edinburgh, or of Ireland.

To become a Fellow of the Royal College of Surgeons of England, a candidate has first to produce evidence that he has been engaged in the study; or the practice and study, of the profession for at least six years after graduation. The only other requirement is that he should pass the examinations, primary and final, set by the Board of Examiners of the College. That is recognized as an extremely arduous task. It demands of the average candidate special preparatory study of several months' duration, with usually the help of a coach or tutor, both for the primary examination in anatomy and physiology and for the final in surgery, surgical anatomy, cadaver operations, and surgical pathology. One who passes these examinations and becomes a Fellow of the College can be depended upon to possess a wide and sound knowledge of these subjects. But it is a curious fact that apprenticeship experience in a hospital is not categorically demanded, and, therefore, the candidate's experience in the performing of operations may be decidedly limited. Even if, as a matter of fact, the majority of the candidates have served for several years as house surgeons, the degree itself guarantees no particular ability in the conduct of operations. That, I think, is the chief defect in the English and Scotch admission to Fellowship, in so far as the F.R.C.S. degree suggests to the public the possession of skill as well as of knowledge.

Let us turn now to the requirements for election to the Fellowship of the American College of Surgeons.

The Board of Regents of the College at the beginning had to make their choice between following the example of the English College of Surgeons, with its notoriously stiff examination, and adopting some less rigid system, which would chiefly take into account a candidate's practical ability in surgery, without troubling much about theory; which, in particular, would not require of him a written or oral examination in either primary or final branches. They chose the latter plan. In view of the deplorable conditions existing in America at that time, respecting the prevalence of incompetent surgery, it seemed better to the Regents to try to elevate the standards of the general mass of surgeons than to establish by severe tests a *corps d'elite*. The majority of us will, I think, agree that at that period their decision in principle was wise. There was, in some degree, an emergency to meet.

The details of the plan of admission to Fellowship, practically unchanged

from the College's foundation, were well set forth by the late Director General, in his Inaugural Address of 1929. Doctor Martin began by describing the standards of examination "adopted and in use by the time-honored Colleges of Surgeons of England, Ireland and Edinburgh." "It was found," he said, "that almost without exception their requirements and tests were formulated before modern surgery came into existence. They are similar to those which are now exacted of internes and hospital aids to ascertain the candidate's knowledge of academic facts, instead of his practical ability to apply such knowledge towards the accomplishment of deeds." He went on to say, "After thorough and careful study of the whole problem there was no reason why we should begin by adapting obsolete plans to a twentieth-century program" (strange words!); and he then proceeded to describe the requirements for admission as Fellow of the American College of Surgeons.

"First: He must have graduated from a medical college approved by the College of Surgeons (or its equivalent); and he must have served at least one year as interne in a creditable hospital and two years as surgical assistant, or he shall give evidence of apprenticeship of equivalent value.

"Second: Five to eight years after graduation in medicine, devoted to special training and to practice, is normally the time requirement for eligibility to Fellowship, so the candidate may prove that he has the proper temperament, and is mentally and mechanically adapted to do surgery.

"Third: The moral and ethical fitness of the candidate as a physician and as a citizen shall be determined by reports of surgeons whose names are submitted by the candidate himself, and by such other reports and data as the Credentials Committee and the administration of the College may obtain.

"Fourth: The professional activity of the candidate shall be restricted to study, diagnosis and operative work in general surgery or in special fields of surgery. His specialization in surgery or one of its specialties must be not less than 80 per cent in communities of more than 50,000 inhabitants, and 50 per cent in smaller communities.

"Fifth: He shall make formal application for Fellowship, which will record full data regarding his educational opportunities, his medical training and post graduate work, and his literary efforts; and he shall give the names of not less than five personal references."

(The rest I shall summarize from Doctor Martin's statement, adding certain comments.)

At this point the candidate's application, together with the replies from his "references," are referred to the State or Provincial Committee of Credentials, which votes to accept, postpone, or reject the applicant. If accepted, he is then required to file complete case records of 50 major operations performed by himself, and brief abstracts of 50 major operations at which he has acted as assistant, or performed himself. These records are then examined by a Central Committee of surgeons in Chicago. This Central Committee, in the past seven years, has had to read carefully from 59,000 up to 67,300 of such case records each year. In 1922, there were 75,600.

In the year 1933, 656 sets of histories were received, and of that number 631 sets, or 63,100 individual histories, were examined in detail by the Committee on History Reviews. Of those reviewed 555 sets were accepted and 76 sets were not accepted. Those whose histories are not accepted have the privilege of later submitting additional histories. Seventeen surgeons of Chicago, drawn from the four leading medical Universities in Chicago, constituted in that year the Committee on History Reviews. This means that approximately 3,712 case records had to be examined by each member of the Committee. "If these records are lacking in any essential, which in the judgement of the Committee can be corrected, the candidate is notified of the fact and an opportunity is given him to supply the omission."

This amounts to a temporary ploughing of only 12 per cent (in 1934 only 9 per cent) and of these 12 per cent it is to be presumed that the majority were later passed, after they had been given an opportunity of correcting or adding to their submitted case records. In justice, however, it should be added that in the last six years the Year Book gives figures which show that of the applications on file in any one year, from 33 to 49 per cent were rejected or postponed by the State or Central Credentials Committees, presumably because the candidates' records did not satisfy the five preliminary requirements. These are not allowed to submit case records, at any rate for the time being. But one may conclude that nearly every applicant who is accepted for examination on the basis of one year as intern and two years' surgical apprenticeship, if his moral and ethical fitness is certified to by "references" submitted by the candidate himself, if a 50 to 80 per cent proportion of his practice is limited to surgery, and if he takes an oath not to split fees, can count upon his being admitted to Fellowship on the basis of his case records.

In the British Dominions we have the Royal Australasian College of Surgeons, founded nine years ago, and the Royal College of Physicians and Surgeons of Canada, founded four years ago. The latter is so young an institution, and its practice, as to examinations, still so much in the formative stage, that it is hardly worth while considering it at any length; but its standards so far are comparable with those of the Royal College of Surgeons of England. In the past three years only six candidates have presented themselves for the final examinations, and of these three have been ploughed.

The Royal College of Surgeons of Australasia, which, on a recent trip to Australia, I had the opportunity of investigating, was founded in 1926, and it is interesting to record that this was due in large measure to the visit to Australia, in 1924, of Dr. W. J. Mayo and the late Dr. Franklin Martin, who, at a meeting in Melbourne, outlined the ideals, aims and opportunities of the American College of Surgeons, and offered a Fellowship of the American College to some 25 leading surgeons of Australia and New Zealand. It was at first a voluntary association, but in 1930 it was incorporated and received from His Majesty King George V a royal charter.

The Australasian College, having clearly in their minds the two systems

of creating Fellows as established in England and in America gradually formulated their own system, which was designed to combine the advantages of both. Their fundamental principle was "to superimpose upon a sound training in the principles of surgery, entailed in the acquisition of a senior surgical degree or diploma, a period of apprenticeship to a senior surgeon in operative and clinical work."¹ Such requirements amounted in practice to demanding of a candidate that he pass the same sort of primary examination as obtains for the Fellowship of the Royal College of Surgeons of England; that is, a stiff examination in anatomy, physiology, and pathology; and of demanding over and above this a sufficiently long experience (five years postgraduate training in surgery as a minimum) in the actual practice of surgery under an approved senior surgeon. This they considered to be much more desirable than the submission of 50 or 100 case reports of operations actually done by the candidate, as in our American system. But they made a proviso that such case reports, if thought necessary, might be required in any particular instance. Credit was given for time spent as a Resident Medical Officer; for work in university departments, and in other countries; for research work; but emphasis was laid chiefly upon the desirability of an apprenticeship period to a senior surgeon. "The practice of attempting to qualify by performing a series of operations, unaided and unsupervised, was viewed with disapproval." Examining Boards were set up, one in Australia and one in New Zealand, called Boards of Censors, each seven in number, over which a Censor in Chief was established. The members of the Board of Censors were the leading surgeons in Australia and in New Zealand. Permission to appear before a Board of Censors as a candidate had first to be obtained from the Censor in Chief, by submission in writing of the candidate's qualifications.

"Full information concerning the candidates granted permission to appear before a Board of Censors is circulated to all members of the appropriate Board. Reports are obtained from surgeons with whom the candidate has worked; his contributions to surgical literature, if any, are studied; and all details of his training are verified. In short, before his interview with the Board, an endeavour is made to determine what manner of man he is. Then follows his appearance before the Board, which, at present, consists of a talk with the candidate extending over a space of 20 minutes upon practical problems in surgery. The expression 'at present' is used advisedly, because the Board has the power to vary the test in the light of its experience. It has found, however, that it is possible to conduct a very searching inquiry during the 20 minutes as to how far a candidate has profited by his training. The decision of the Board does not depend exclusively upon the answers given by the candidate in this space of time, for it also gives credit for the work he has done during the training period. Adequate time is allowed after each interview for a consultation among members of the Board upon the merits and demerits of each candidate, based partly upon their personal observation of him and partly upon the reports received concerning the work he has done.

"Candidates rejected by the Board must undergo a further period of training before permission is granted to reappear before it."

One notes that the stiff Final Examination of the Royal College of Surgeons of England is reduced to a short oral examination, and is, in fact, replaced by the long period of apprenticeship.

I confess that I was most favorably impressed with the Australasian system.

In Germany, so far as I know, there exists no particular examining body corresponding with the Royal College of Surgeons of England, or the American College of Surgeons, through which a young surgeon may obtain a higher degree or diploma. Medical education, both undergraduate and graduate, is ultimately controlled by the State; that is, by a Federal ministry, although naturally the various universities, all State-founded and State-supported, undertake the actual work of medical instruction, and act as examining bodies.

There are, however, two postgraduate university degrees open to the ambitious in many professions, including surgery—the habilitation and the Dozentur, or permission to teach. These, before last January, were essentially identical, and could be acquired in one and the same examination. Under the new law of this year these were separated, and habilitation became a title or degree standing on its own feet. The candidate who passed his habilitation examination might or might not proceed to the higher degree of Dozent, which was reserved to those who aimed at a teaching position in Universities and High Schools. Habilitation was a necessary stage towards the Dozentur. Habilitation, therefore, became a new academic degree, which was to be obtained only through independent scientific work, considerably in advance of the requirements for the ordinary graduation degree of Doctor, and the license to practice. To acquire the Dozentur, that is, to become a Privat Dozent, there was demanded in addition to the habilitation standards, definite proof of the candidate's teaching ability, and above all, of his qualifications in person and in character for the profession of teacher.

The requirements for the degree of habilitation are now as follows:

The candidate is not eligible for the examination before the third year after graduation. His title consists in the addition of the word "habilitiert" (abbreviated to habil.) to his University degree, as, for instance, "Dr.Med.habil." Application for the degree must be made to the appropriate Faculty. The details of his educational career and his publications are to be submitted. The actual habilitation examination consists in the presentation of a thesis, which must be published within the ensuing year. After acceptance of the thesis the Faculty summons the candidate to an open scientific discussion, in the presence of the University "Rektor," or Principal. This discussion, or examination, may be upon any part of the candidate's specialty. If accepted by the Faculty he is recommended to the State Ministry of Education, which, if it agrees, refers him back to the Faculty for the actual awarding of the degree.

It is, therefore, seen that, in Germany, there exists this higher degree of habilitation in surgery, which may guarantee to the public a certain amount of advanced knowledge. To me the requirements seem less exacting than those of either the English or the American Fellowship. They do not demand particular evidence of a knowledge either of the basic sciences or of practical surgical experience. But they do demand evidence of ability in research, clinical or experimental, and of an advanced clinical knowledge.

As to the degree of Privat Dozent, only those are eligible who can be accepted as teachers. The Faculty invites the applicant to a public test of his teaching ability. On three different days within one week he is asked to give a public lecture of three hours' total duration upon a subject or subjects in his specialty. The subject of his lecture is chosen by the Faculty out of three submitted by the applicant. The "Rektor" of the University, the teaching members, and also students are invited. After being accepted the candidate still has to go through a period of service in a Community Camp, and in a "Dozentenakademie."

In so far as university teaching, skilled hospital work, and the advancement of research are concerned, the needs of the higher surgery have always been well looked after by the class of Privat Dozenten, but these can fill as practising surgeons only a limited portion of the needs of the general population, outside the university clinics and the larger non-teaching municipal hospitals, for capable and advanced surgery. This second large field of necessary work, in towns and villages, which is so much in my mind, for which the Royal College of Surgeons of England, and the American College of Surgeons does so much, is taken care of presumably by those who have gained the habilitation degree, and by men who have been Voluntaer-Assistenten in the larger clinics, but have failed to secure hospital appointments, still less teaching appointments, or the higher positions in non-teaching municipal hospitals. If a surgically ambitious man is thus forced to settle in a comparatively small community, and is, nevertheless, well trained in practical surgery, he can point at best to such qualifications as those just mentioned. I doubt if in the eyes of the public the habilitation degree carries as much weight as the F.R.C.S., or the F.A.C.S.

In France a somewhat similar condition of affairs obtains, but without, so far as I know, any degree corresponding to the German habilitation. Here the man, ambitious to become a surgeon, has open to him, first, the Internat, which means in brief that before graduation, during his clinical years as a student, through a stiff competitive examination, he may secure an appointment as intern in any large hospital, in the service of a senior surgeon. In this position he undoubtedly acquires, during his term of five years of service, a large experience in general surgery, as well as in the French method of teaching. He often does not take the final examination for his degree in the university, and his license to practise, until the end of his internship. After this, if he is lucky, he may be allowed to serve in some large teaching hospital, as a sort of voluntary assistant, meanwhile devoting himself to study and to

research in preparation for the higher degrees of Chirurgien des Hôpitaux, and Agrégé. These are both decidedly difficult competitions, there being many candidates for relatively few positions. The examination demands a thesis, and the delivery of one or more clinical lectures before a jury. The Agrégé corresponds more or less with the Privat Dozent in Germany. From the class of the Agrégés the higher positions of chief surgeon and professor are recruited, and in this way the upper levels of surgical achievement in France are adequately filled. As in Germany, also, the surgical work in the larger non-teaching municipal hospitals throughout the country is taken care of by well-trained men, who have not tried, or have failed to secure positions in the metropolitan clinics. But again, as in Germany, the needs of the country and the smaller towns for competent surgery have to be met by "interns" who may have failed in their Agrégé examinations, and these cannot write after their names what might correspond to F.R.C.S., or F.A.C.S., as a legitimate indication to the public that they have had an adequate training in their specialty, for there exists no examining body to give them such special diplomas. They endeavor to secure the advantage of this legitimate form of advertising by putting in brackets after their names, say on their letter-heads, "Ancien interne" of such and such a hospital clinic. Yet, as a matter of fact, an "ancien interne" will often have acquired a clinical experience and an operative ability decidedly superior to that of our Fellows of the English or American Colleges.

It is inevitable after such a review that one should go on to compare these various systems. France and Germany may as well be left out, as their point of view is so different. There remain the other three. What, in résumé, are the chief differences between these three systems? Let us set them forth briefly under headings.

(1) *Character.* Moral and Ethical Fitness.

In England, no particular attempt is made to ascertain this. Apparently one assumes it. And that assumption seems to be justified. In America and in Australasia, inquiries are addressed to the five gentlemen whose names have been given by the candidate as his "references," and to the surgeons under whom he has served his apprenticeship.

(2) *Basic Sciences.* Anatomy, Physiology, and Biochemistry.

In England and Australasia, the candidate must pass a stiff examination in these subjects, an examination which is counted harder than the ordinary one for undergraduate students. Many fail. The candidate may go up for this examination during his undergraduate course, after passing the Primary of his medical school. In America, no such examination is required. It is apparently assumed that the knowledge of these subjects acquired during his undergraduate course, and his postgraduate clinical training, remains with him. (A dubious assumption!).

(3) *Surgery and Surgical Pathology.*

In England there is a written examination, followed by an oral on clinical

cases, and on pathologic specimens; also an examination in operative surgery on the dead body. Usually from 40 to 60 per cent are ploughed.

In Australasia, the examination is only an oral one of 20 minutes before a Board of Censors, composed of seven of the leading surgeons. Chief reliance is placed on the evidence of a long apprenticeship in a hospital under a recognized senior surgeon.

In America, the candidate is not seen by the examiners. His examination consists of his 100 case reports, which are assumed to show forth sufficiently his knowledge of surgery. Knowledge of surgical pathology remains unexplored.

(4) *Postgraduate Period of Apprenticeship Necessary for Eligibility.*

In England, six years, but no period of surgical apprenticeship is specifically demanded. In practise, the examination is of such a nature that very few men who lack a thorough hospital training in surgical wards can hope to get through.

In America, "five to eight years after graduation in Medicine, devoted to special training and to practise, is normally the time requirement for eligibility to Fellowship." As to "special training," "at least one year must be spent as interne in a creditable hospital, and two years as surgical assistant, or evidence must be given of apprenticeship of equal value." The balance of two to five years may apparently be spent in "practise."

In Australasia, "a minimum of five years' postgraduate training in surgery under an approved senior surgeon."

(5) *Evidence of Operative Ability.*

In England none is specifically demanded, although the majority of candidates have in their hospital training acquired a certain competency in operating.

In Australasia the same is true but the evidence of the senior surgeon or surgeons under whom the apprenticeship has been served is relied on for information in this respect.

In America the submission of 50 case records of patients upon whom the candidate has himself operated, and of 50 abstracts of case records of patients at whose operations he has acted as assistant.

Such a comparison must lead, in all of us, to some opinion concerning relative merits. For my own part, I feel that it is legitimate to express a personal opinion quite frankly. And that opinion is in favor of the Australasian system, because it alone satisfies my, possibly old-fashioned, ideals. A good practical knowledge of the basic sciences, including surgical pathology, and a relatively long apprenticeship under the direct supervision of a surgeon of unquestioned authority, ought to constitute the essentials in the training of a real surgeon. The other systems lack one or both of these requirements.

At the beginning of these remarks, I made a plea for the establishment of a higher degree in surgery in this country. That obviously implied a dissatisfaction with the only degree we now have, that of the F.A.C.S. The chief ideas in my mind were, first, that that part of the general public not served by high-class hospitals had still an equal need of well trained surgeons; and, second, that the American College of Surgeons was not properly supply-

ing that need in respect of the qualifications of its Fellows as surgical specialists. This amounts to saying that the requirements of admission demanded too little of the candidates. The Regents in 1914, to meet an emergency, made the standards of admission relatively low (as compared with England), as a matter of material policy. That policy was, however, also idealistic in its program of education. To you here present, most of whom are Fellows of the College, it is unnecessary to emphasize the real achievement which this policy of education has accomplished in elevating surgical standards throughout the country, or to point out the large amount of progressive work along selected lines which has been carried out by the College in its inspection of hospitals, its committees on bone sarcoma, fractures, cancer clinics, surgical education, and the rest. But we have to remember that this educational part of the College work is done by the leaders, by the highest type of surgeon that America produces. It is finer, more extensive, more effective than that carried on by any other surgical society of which I know.

But what about that other and greater side of its work, the Fellowship? What about the Requirements for Admission? In principle, if the rank and file of the candidates are admitted too easily, by tests which are too easy, it can do nothing but lower the general name and reputation of the College. It is not enough to say that men may justifiably be admitted easily in order to educate them to higher standards. A certain reasonably high level of attainment on the part of its new Fellows ought to be exacted by the College, because the good name of the College will chiefly stand or fall upon the reputation of its individual Fellows practising in their individual communities. Therefore, that part of the College's original policy definitely announced by the Director General in 1914 which aimed at numbers, at having "every surgeon on the Continent who can fulfil the membership requirements become a Fellow of the organization," which consisted of gathering in as many applicants as possible for Fellowship, in urging Credentials Committees in all states and provinces to bring in by suggestion and encouragement all possible candidates (the "highways and hedges" policy, as it has been called), has naturally given some justification for the criticism of those who thought that the standard of requirements for admission to Fellowship was being sacrificed in favor of the ideal of numbers as opposed to the ideal of unimpeachable qualifications.

It has always seemed to me in reading the yearbook of the College, and the addresses pronounced at Congresses by the Founders and leaders, that there was a curious contradiction between these two policies. The requirements for admission to Fellowship, in regard to knowledge, seemed, at any rate to many of us, much too lax in respect of surgical knowledge, yet the aspirations of the leaders were always high. Let me quote a few paragraphs from various addresses:

In 1913, at the Third Convocation, Doctor Bradford said: "It has been said by those who undertake to study the American people that the typical American, although energetic, resourceful, and venturesome, *lacks a knowledge of fundamentals*. He has the defects as well as the virtues of the pioneer. Are these traits characteristic of the Amer-

ican surgeon? If they are, the facts should be reckoned with in our plans for the training and education of our surgeons. We should foster the energy of the pioneer and give to him the *fundamental knowledge needed by a master.*"

In 1929, Dr. W. J. Mayo, in the Fellowship Address, said: "I hope that the time will come when every young surgeon, after special training of at least three years, will take a *master's degree in surgery*, and will train himself with a view of gaining surgical recognition that will entitle him to join the College: You may become a good operator by staying at home and sticking strictly to business, but not a good surgeon. It is the *mental outlook of the surgeon and not the hands that is most important.*"*

These should be our ideals. But can we claim that the requirements for admission as formulated by the Founders of the College satisfied those ideals? I should answer "yes," as regards the character of candidates, but "no" as regards the evidence of their surgical knowledge and skill.

It may be urged that standards and ideals differ greatly, and that the standard of the Fellowship does fulfil a reasonable ideal. Any argument presupposes an agreement upon definitions. What is the definition, at the present day, of the term surgeon? I conceive of it thus: In ancient Greece, the surgeon was, as the etymology of the word shows, "one who worked with his hands." There are some, even in these times, whose conception of the surgeon rises no higher. But we may accept skill in handicraft as an integral part of the definition. The surgeon should know how to do the mechanical side of his job. That is called the Art of Surgery. What must he know of the Science of Surgery? As the abnormal is derived from the normal, the surgeon must be familiar with both. He must know his surgical applied anatomy, both normal and pathologic, and his surgical applied physiology, and his surgical applied biochemistry, and his surgical pathology, for all of them are necessary to the understanding and to the intelligent treatment of surgical diseases and injuries. I say "applied" to indicate that an extensive knowledge of "pure" anatomy, physiology, and so on, is not to be demanded, but only a knowledge of fundamentals and their application to the science and art of surgery. Yet, these are the basic sciences; and lacking a reasonable knowledge of them, the surgeon is no true surgeon but an empiricist, a rule-of-thumb man. *Rerum cognoscere causas!* The empiric and the charlatan know nothing of causes; the surgeon must. It is the basic sciences which enable him to trace causes, and so to understand disease.

The third requisite is clinical experience, that is, at the bedside, and necessarily in a large hospital. This gives the young surgeon knowledge through repetition and variety. But in order that he should not gain experience at the expense of the patient, he must be taught by one of the elders, and guided. He must, therefore, be apprenticed to a Master Surgeon, and for a reasonably long period.

From this argument I deduce that a sound knowledge of the basic sciences and a long apprenticeship under a Master in the Guild are the chief requisites in the development of the surgeon. And they are requisites alike for the small-town surgeon and for him of the metropolis.

* (*Italics the writer's.*)

How, then, is the apprentice to gain the coveted title of surgeon? How but by examination? How save through the imprimatur of the Masters?

Who should set the standards of such examinations? Surely the Guild Masters. Who should award the title? Again the Masters of the Guild of Surgeons. And if the standards set by the Guild Masters are low, if the examination is made easy, if basic sciences are counted unnecessary, if the apprenticeship term is short, if the handicraft is exalted and science is made little of, then will the value of the Guild's title of surgeon be counted low.

If these principles are accepted, if we hold to these ideals, then the questions at issue are:

First, by what means can we best provide the country with a sufficient number of surgeons who fulfil these ideals?

Second, assuming that the Fellowship of the American College of Surgeons is at present the only degree or diploma which certifies to the public that the holder is a "surgeon," or specialist in surgery, are the tests leading to the acquirement of such Fellowship sufficiently stringent to assure these ideals?

Third, if we conclude that they are not, then what measures should be taken to remedy this state of affairs? Should the College's system of examinations be altered or added to in order to make admission more difficult, to demand a deeper and wider knowledge of surgery? Or should we establish an independent Board of Examiners with power to grant a higher degree to successful candidates, say Master in Surgery? (This last is no new idea. Doctor Bevan suggested, though in another connection, in his Presidential Address two years ago, the creation of a new degree, that of Master of Surgery.)

For my own part, I can only record personal opinions. In doing so, I desire most sincerely to avoid being dogmatic or hypercritical. I know from correspondence and discussion that some, probably many, of the leaders of the College are genuinely convinced of the soundness of the system, and that, certain defects admitted, they are steadily endeavoring to improve it. Our difference is one of principle; and that concerns chiefly the character of the examination (one hundred case reports) and the kind and duration of the apprenticeship period. Answering, then, the questions at issue just posed, I venture to make a few observations and suggestions.

The means of providing the country with surgeons of the ideal stamp are to be found in the establishment of a Board of Examiners who hold these ideals; and also by a wider and better organized system of utilizing our outstanding hospital services throughout the country for the training of such prospective surgeons.

I cannot but feel that the Admission requirements of the American College of Surgeons are not stringent enough to assure such ideals. In what ways, then, are they lacking? The number of State and Provincial Credentials Committees must amount to close upon 60. Their judgment upon the moral and ethical fitness of candidates may well be accepted, but their standards

as regards training, scientific knowledge and operative ability must vary considerably from State to State, and may easily be set too low.

The system of 100 case records as representing a final examination allows too easily "leaks" of various sorts, and gives too little information concerning the candidate's surgical capacity, either in judgment or in handicraft. There is lacking the intimate knowledge of the candidate's ability which is provided in the Australasian system by the supervision of a senior surgeon. The record of 50 major operations "unaided and unsupervised," may mean much, it is true, but may mean very little.

The candidate is rarely, if ever, seen by the Board of Examiners who pass him. A very small percentage are ultimately rejected. The system tends to emphasize ability to perform routine operations, without taking much account of the candidate's knowledge of the science of surgery. Can such case records make clear his knowledge of anatomy, physiology, pathology, or even operative technic? Do they include any reasonably wide variety of surgical diseases and operations? In short, is the system of case reports sound? For my own part, I think it is not. It was designed to give the public a guarantee that the holder of the diploma was a better surgeon than the type which previously flourished; and to provide quickly a large number of practical surgeons to displace these. As a result the College has given its Fellowship in the 21 years since its founding in 1913, and including the original 450 Founders, to a total of 13,895 surgeons. That makes on my computation (very roughly) about one surgeon to every seven or eight medical graduates in general practise, excluding those who take up specialties or go into State or institutional service. And with that we have not counted the large number of surgeons who do not belong to the American College of Surgeons. The very number indicates that the standard of admission is, to say the least, not exacting. Is it not time to take a step higher? (The Royal College of Surgeons of England has admitted in the last sixty years less than 2,000 Fellows!)

In saying all this, I do not wish to indicate that the rank and file of the Fellows are on the average unworthy members of the surgical profession (though some are!) They have had a surgical training of sorts, often of a very good sort; and they undoubtedly do a vast amount of creditable surgery. But I do feel that the title of F.A.C.S. is too high, too fine a one for many of those who are accepted. The dignity of the title has been lowered by too easy admission. The weight and significance it carries with the public is also undeserved by the surgical knowledge of not a few of those to whom it is granted.

My plea, therefore, is that some new departure be now made, some new step taken, with the object of making better provision for the country's need of thoroughly trained surgeons, and of augmenting the dignity of the surgical profession on this continent. My belief is that we can only do this by creating an independent higher-degree demanding a stricter examination, both in fundamental principles and in practice. Whether that degree should be created inside the American College of Surgeons, or outside it, or perhaps

preferably, by a collaboration of all representative surgical associations, I leave undecided. A general board, consisting of representatives from this Association, the American College of Surgeons, the Surgical Section of the American Medical Association, the Federal Examining Board, the Universities, and possibly others, is what naturally suggests itself. Such a Board, demanding a reasonably high level of surgical knowledge and skill, and awarding by examination a new and higher degree, would safeguard the public, satisfy our own sense of rightness, and do much to raise, in the average, the reputation of American Surgery.

The *modus operandi* of establishing such a higher degree, or certificate, presents undoubted difficulties of detail. But the work already done in various countries, and especially by the Council on Medical Education of the American Medical Association, on qualifications of specialists, should form a good lead. Time is lacking to review this aspect of the subject, and I fear that I have far overstepped my time. Perhaps a President's privilege may excuse that!

Gentlemen, our profession is sometimes, by the more emotional of our patients called "noble." Let us neglect the somewhat hackneyed implication of the word and realize that the phrase is, or should be, essentially true. From Hippocrates to our day those who have practised the healing art have had the blessed heritage of the Hippocratic Oath,—that pledge which lends to a profession already made fine by service a peculiar worthiness and dignity. And Old Burton said somewhere in his *Anatomy of Melancholy*: "One thing I would require of every physician—honesty!" To that we may well add, in these wonderful times of increased and rapidly increasing knowledge, judgment and skill. These we owe as professional obligations to our patients. But this is not all. One more duty is incumbent upon us; that of providing or helping to provide workers of undoubted capacity as our successors.

In our hands as surgeons are the graver issues, not seldom of life—or of death! And that more immediately than in any other branch of medicine, because we oppose disease by an act which of itself may bring danger. Dame Nature often presents prematurely her account for the debt which ultimately is due her from all of us. Ours is the task and privilege of interfering to prevent payment before the proper date of maturity. That can best be done if we, and those we teach, acquire the judgment and skill necessary to defeat the Old Dame! Those we teach! Yes, but also examine. For our successors should be better surgeons than we are. Our Guild has its Masters; and we must see to it that our apprentices, by instruction *and through examination*, become Masters. This, in brief, is the thought that underlies all that I have said this morning. We must continually strive, for our posterity as well as for ourselves, towards higher standards in that profession which is at once our anxiety, our pride, and, I trust, sometimes our glory.

REFERENCE

- ¹ Mr. Alan Newton, Censor in Chief. *Handbook of the Royal Australasian College of Surgeons*, p. 35. Melbourne, February, 1935.

SYMPOSIUM
ON
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UNDERGRADUATE TEACHING OF SURGERY

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GRADUATE TEACHING OF SURGERY IN UNIVERSITY CLINICS

GEORGE J. HEUER, M.D., New York, N. Y.

OPPORTUNITIES FOR GRADUATE TEACHING OF SURGERY
IN LARGER QUALIFIED HOSPITALS

ALLEN O. WHIPPLE, M.D., New York, N. Y.

DISCUSSIONS BY

ARTHUR DEAN BEVAN, M.D.

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UNDERGRADUATE TEACHING OF SURGERY

ELLIOTT C. CUTLER, M.D.

BOSTON, MASS.

MOST of those assembled here are teachers by profession and all are teachers in fact, for all successful doctors are thoroughly imbued with these lines of the Hippocratic oath, "To teach them this art if they shall wish to learn it." Thus the exercises of today are a part of our faith and are to be treated as an expression of our most sincere thought. Medical education in the last 30 years has undergone an enormous change, a change of tremendous benefit to the public welfare. The American Medical Association began in 1907 classifying medical schools on the basis of their buildings, equipment, personnel, administration, and the results of the examination of the graduates of each school for the license to practice medicine. In 1910 appeared the Flexner report to the Carnegie Foundation for the Advancement of Teaching on "Medical Education in the United States and Canada." In 1925 the Commission on Medical Education was organized by the Association of American Medical Colleges and has issued both in pamphlet and book form careful studies of the whole subject of medical education. During this period of 30 years, under the pressure of criticism and suggestions from commissions and individuals, our medical schools have been practically rebuilt and entirely reorganized. Vast sums have been given not only for the practical construction of satisfactory teaching units, but for the endowment of the teaching force itself. The struggle for efficiency has resulted in a very satisfactory competition, a competition ultimately giving to us the survival of the fit and the loss of schools which could not or did not find the funds to improve their material, equipment, and their teaching force. As a result, in 1934 there were 77 Class A or approved medical schools with 22,799 students, as against 160 schools of this type in 1905 with an enrollment of 26,147 as recorded in the first report of the Council on Medical Education and Hospitals of the American Medical Association in 1907.

Unfortunately, the impetus toward improvement has been entirely upon undergraduate education and we have now reached the peculiar position in our country where we turn out a great number of well trained young men from our medical schools, but have a totally inadequate mechanism for giving them the necessary practical and special training and experience during the first few years after graduation, so that they may practice the dangerous specialties of their profession with safety. This lack is perhaps more glaring in relation to surgery and its specialties because of the actual danger inherent in surgical practice, but roentgenology, also a dangerous technic, is in a similar situation, and the medical specialties, though not so apt to result in serious mistakes of commission, are from the point of view of the public health in a similar position. Legally there are no restrictions once a graduate has passed his state

licensing board examinations and this is a matter generally undertaken and completed immediately upon graduation from the medical school. Thus the American public may legally be cared for, indeed, subjected to a dangerous surgical procedure, by a student who has just been graduated from medical school.

This creates an entirely anomalous situation, for, as we shall see later, every teacher of repute in the realm of surgery agrees that it is not his duty to teach the undergraduate medical student practical surgery. He feels it his task to train the young student in the principles of surgery, the basis of asepsis, gentleness, support, the principles of anesthesia and how to care for trauma and minor sepsis, matters which constitute such a large share of the general practice of medicine. And our good teachers are almost unanimous in their opinion that the teaching of the technical steps of major surgery is a post-graduate problem. This means that we teach less technical surgery than 20 years ago, but that we permit (legally) this untrained individual to practice his art upon, let us be frank, the unsuspecting public. We cannot allow this situation to persist and it is clear that the problem which is to be confronted will largely be concerned with this graduate education which we have so sorely neglected. It is our responsibility and our duty to see that steps are now taken to remedy this matter.

As an introduction to the phase of graduate and postgraduate training of the surgeon, there must be some statement of what his equipment is or should be by the time he graduates from medical school. Surgery is definitely a post-graduate problem. At the same time, since a large proportion of the general practitioner's patients suffer from disorders for which minor surgery is the chief therapeutic agent, every medical school must provide its students with teaching and experience in the elements and principles of surgery and particularly in the care of individuals suffering from injury and infection. This necessitates grounding in the matter of asepsis, sterilization and the whole relation of bacteriology to clinical surgery. It necessitates a satisfactory knowledge of the ability of the body to repair damage and thus courses in surgical pathology—the healing of the wound and the reaction to foreign bodies—are necessary parts of the early training of our young undergraduate medical student. This matter also necessitates competent knowledge and training in the use of the simpler anesthetics. I have long looked upon the principles of surgery as the methods by which we obviate pain, hemorrhage, and sepsis, and I feel that if a student is well grounded in the meaning of these simple conditions and has some practical clinical experience in the realm of trauma and sepsis, he is competent to care for the simpler injuries and infections which come to the office of a general practitioner.

In addition to such training, the undergraduate student must be shown by members of the department of surgery those forms of disease for which surgery is the chief therapeutic agent. It is only proper that the surgeon should teach concerning the disorders which he cares for, demonstrating these

to the students not from the point of view of the therapy but so that the students may know which disorders should be treated by surgery and also know something of the dangers and complications of the surgical undertaking. This necessity of discussing disorders for which surgery is the chief therapeutic agent also clearly points out that the surgeon must share in the original instruction given to medical students in history taking and physical diagnosis, which are our fundamental methods in reaching a diagnosis. For example, the surgeon is the one to teach the medical student proper abdominal examination. He is the one with the greater experience concerning the art of distinguishing between voluntary and involuntary spasm, having learned this by proving his diagnosis daily in the operating room. He also is the one who must teach many of the special examinations, the gynecologic examination, digital examination of the rectum; and his specialist colleagues must add to this the methods of examining the ears, the nasal passages, and the mouth.

Even this short list of topics is enough to consume, if these matters be properly taught, all the time a department of surgery will ever be given by a curriculum committee and should any of the time which a department of surgery is given be utilized by the students in watching operations or trying to understand the technical details of procedures, just so much less will the student know of the fundamentals upon which he is to build his education. Just how the time and the curriculum are to be divided is a matter of practical concern to the teachers, though the principles enunciated above are of far greater importance than any details of the curriculum.

The curriculum in practically all American medical schools follows the block system. The basic sciences occupy the greater part of the first two years and the last two years are given over to clinical study. Thus a study of the normal logically precedes the study of the abnormal (disease). In some centers the separation of these two considerations of medical education has been emphasized by the setting up of the basic medical sciences and the clinical work into almost separate schools. Such a tendency seems to some unwise since it accentuates the natural thought of the student that the sciences are something to get through with in order to study medicine. But in all schools there are given at some time between the training in the medical sciences and the clinical years general introductory courses in medicine and surgery. The chief aim of such propaedeutical instruction is to equip the students with methods and tests for determining the normal and its variations. Thus history taking and physical diagnosis which constitute our chief clinical methods occupy this first time in clinical teaching. It is true that the department of surgery in some schools assists in the teaching of anatomy but beginning at this time it must assume a major responsibility. Here arises the question as to how much instruction in history taking and physical diagnosis the surgeon is to give. Shall he, independent of what his sister department of medicine is teaching, cover the whole field? In some schools this seems to be the case,

though in the majority of schools the chief instruction in this important matter is given entirely to the department of medicine. In a few schools excellent cooperation obtains between the departments and in such schools the responsibility for special examinations only is left to the surgeon. Thus the abdominal examination, the rectal examination, and the vaginal examination belong to the general surgeon, the neurologic examination to the neurologist, and the examination of the eye, ear, nose and throat to the appropriate specialist. It is fair to point out that the correct handling of this introductory course is less well standardized than the remainder of the teaching. In some schools only history taking and physical diagnosis occur at this time; in others, courses in surgical technic, the methods of sterilization, enough surgical pathology at least to cover the healing of the wound, the principles of anesthesia and the beginnings of a study of trauma and sepsis, though both laboratory and clinical experience, precede the actual contact with patients.

The curriculum for the last two years is well standardized. Didactic lectures and clinics give to the student a skeleton of regional surgery on which to hang his varied ward and out-patient experiences. The exact order of these last two years is somewhat divided. In about one quarter of the schools the third year men are clinical clerks on the wards, and in the quiet of such surroundings, with plenty of time, begin to practice history taking and physical diagnosis. In such schools the student spends his last year in the dispensary or out-patient department. But in the majority of schools this order is still reversed and the third year students in small groups with an instructor are acquainted with disease in the out-patient departments, spending their fourth year on the hospital wards as clinical clerks. It seems to me that there is little to choose between in the methods if both are well done, for the objection that the rush and bustle of an out-patient department is no place for a beginner may not be true if special rooms and a competent instructor are available, and the very variety of material, and especially the emphasis on trauma and infection, may be of great value at this time.

Some years ago the American College of Surgeons made a start in studying the education of the surgeon, but the College found greater interest in other matters and even reports of the studies made at that time were not published. Now, some years later, the original studies started at that time have been amplified and we can today present to you the opinions of the heads of teaching departments in 51 of the 77 Class A or approved medical schools in this country. The unanimity of opinion concerning undergraduate education is so striking that there can be little doubt but that this phase of surgical education is now well understood, well standardized, and fairly well taught in practically all of our Grade A schools. Moreover, I have had the opportunity in the last five years to visit at least 20 of our leading schools and in addition to what the professors in charge have said have had ample opportunity to get the student's reaction, both during his undergraduate days and immediately upon graduation. The standardization of undergraduate education is almost startling. It is true that the teaching of fractures, anes-

thesia and the amount of time given to the surgical specialties all vary widely, but that is largely because of the type and supply of material, not because the teachers themselves have a divergent opinion of what it is wisest to teach.

The original questionnaire sent out to the Class A medical schools contained the following general and specific questions:

TABLE I

- (A) What are the important matters to teach the undergraduate medical student? (Comments here on over- or under-emphasis of specialties would strongly apply.)
- (B) What is the order of teaching (by topics in years)?
- (C) How much time in general is required in the curriculum?
- (D) We would in particular like specific answers to the following questions:
 - (1) What do you consider the most important matters for a department of surgery to give to undergraduate medical students?
 - (2) Do you consider it your duty to teach practical operative surgery?
 - (3) Do you teach sufficiently well and do you have time and materials enough in your curriculum to satisfy yourself that you are covering carefully the following:
 - (a) the care of trauma, including fractures;
 - (b) the care of ordinary sepsis;
 - (c) anesthesia?

The answers to these questions are summarized in Tables II, III, IV, and V.

TABLE II

What Are the Important Matters to Teach the Undergraduate Medical Student?

Surgical diagnosis.....	32
The principles of surgery.....	30
Keep specialties in the background.....	28
The basic courses.....	16
Trauma and sepsis.....	13
Clinical surgery.....	8
The indications for surgery.....	5
Ambulatory surgery (minor surgery).....	5
Preoperative and postoperative care.....	4

The answers to Question A, given above in Table II, are almost a summary of the other expressions which are to follow and make it very clear that the teachers of surgery consider surgical diagnosis, the principles of surgery, and the care of trauma and sepsis their first obligations. It is of interest that a majority of the teachers must see some danger in overspecialization early in the student's career, in that they have definitely stated that the specialties should not be greatly emphasized.

A study of Table III, which gives the answers to Question B, shows some variability in the exact sequence of teaching topics, but on the whole there is not so much divergence as the number of specific courses would seem to indicate. In the first year, two schools do teach surgical anatomy, one minor sur-

gery and one gives amphitheater clinics. As a matter of fact, in a good many schools the teachers in the department of surgery do assist in the anatomic instruction, and quite properly so, but their responsibility is, in these schools, in the department of anatomy and not in the department of surgery.

For practical considerations, we may say the first year is devoted entirely to the basic medical sciences.

TABLE III

What Is the Order of Teaching (by Topics in Years)?

<i>First Year</i>			
		Orthopedics.....	5
Surgical anatomy.....	2	Animal surgery.....	5
Physiology.....	1	Urology.....	4
Biologic chemistry.....	1	Anesthesia.....	4
Neuro-anatomy.....	1	Regional surgery.....	3
Histology.....	1	Specialties.....	3
Dissection.....	1	Anatomy.....	2
Minor surgery.....	1	Abdominal surgery.....	1
Surgical amphitheater clinics.....	1	Tumors.....	1
		Diseases of rectum.....	1
<i>Second Year</i>		Externship.....	1
Principles of surgery.....	17	Surg. body, surface and extrem.....	1
Minor surgery.....	9	Medicine.....	1
Basic sciences.....	8	Public health.....	1
Physical diagnosis.....	7		
Surgical anatomy.....	6	<i>Fourth Year</i>	
Surgical lectures.....	5	Clinical clerkship.....	30
Clinical teaching.....	3	General surg. clinic.....	16
Dry clinics.....	3	Out-pt. case taking and dispensary.....	14
History of surgery.....	2	Surgical pathology.....	9
Surgical technic.....	1	Ward rounds.....	8
Medicine.....	1	Gen. surg. lectures.....	6
Fractures I.....	1	Anesthesia.....	6
		Surgical diagnosis.....	6
<i>Third Year</i>		Regional surgery.....	5
Didactic course in surgery.....	17	Operating room work.....	5
Dispensary teaching.....	15	Special clinics.....	4
Principles of surgery.....	13	G-U lectures.....	4
Surgical pathology.....	13	Specialties.....	3
Fractures.....	12	Surg. head, thorax, abdomen.....	2
General surgical clinic.....	12	Roentgenology.....	2
Surgical diagnosis.....	9	Neurologic surgery.....	2
Clinical clerkship.....	8	Surgical anatomy.....	2
Operative technic.....	7	Industrial surgery.....	2
Examinations and case taking.....	6	Orthopedics.....	2
Ward rounds.....	5	Animal surgery.....	1

In the second year occurs the introductory course in surgery, given different names, apparently, in different schools. Thus, though the title "principles of surgery" receives the greatest number of votes, minor surgery, physical diagnosis, surgical lectures, clinical teaching, surgical diagnosis, *etc.*, might well all be classified under the same heading.

In the third year there is a great array of topics under which the department of surgery teaches. Apparently, in some schools the principles of surgery do not begin until the third year, and in these schools, indeed, there is no surgical teaching in the second year. On the whole, dispensary teaching and a didactic course, as a skeleton on which the students are to hang their general experience, constitute the major items in that year. The course in surgical pathology appears as a part of the surgical curriculum in some schools, but in others this topic through cooperation is taught by the department of pathology, so that the figures here do not necessarily mean that surgical pathology is taught in only 13 schools. The eight schools which give a clinical clerkship in the third year instead of the fourth year are, as a rule, greatly pleased with this shift of the curriculum and feel that the student should practice early in his career his methods of history taking and physical diagnosis and can practice them, indeed, to better effect in the quiet of the ward than in the busy dispensary. This is the only really important consideration in these last two years, for the remainder of the topics taught and listed here are fitted into most schools in one way or another even if they do not appear as separate courses.

In the fourth year the general clinical clerkship, supported by a surgical clinic once a week, is the usual method of teaching. In some schools, as already noted, the fourth year men work in the dispensary and out-patient department and, indeed, in some of the schools, where the clinical clerkship occurs in the fourth year, these men are in addition sent out for a more varied experience, for a part of this period of training, to the out-patient department. The general list of other topics shows again some separate courses in surgical pathology and in some schools ward rounds are listed as a separate course, and operating room work and some specialties creep in as special courses. The large number of topics, however, does not at all express the unanimity of the form of teaching but merely means that different teachers give different names to their courses. For example, one school lists only a clinical clerkship, whereas during this clinical clerkship there is teaching in surgical pathology, ward rounds, operating room work, instruction in the specialties—matters which in another school are all listed separately.

The answers to Question C, "How much time in general is required in the curriculum?", were so involved with peculiarities of the curricula in many schools that only a few seemed of value in this summary. I found difficulty in counting hours since in some schools laboratory and clinical hours are graded as only half the value of lecture hours. In the 13 schools where a reasonably accurate comparison could be made, second year teaching averaged 49 hours, third year teaching, 257 hours, and fourth year teaching, 329 hours, giving an average total surgical hours in the curricula of 637 hours. Unfortunately, I have not the total curriculum hours for these 13 schools, so that the relation of this 637 to the total is not available. The total is probably in the neighborhood of 3,500 hours.

TABLE IV

*What Do You Consider the Most Important Matters for
a Department of Surgery to Give to Undergraduate
Medical Students?*

Surgical diagnosis and clinical surgery.....	38
Principles of surgery.....	30
Surgical pathology.....	19
Indications for surgery.....	13
Trauma and sepsis.....	11
Basic sciences.....	9
Physical examination of patients.....	8
Minor surgery.....	5
Urgent surgery.....	3
History of surgery.....	2
Knowledge of literature.....	1
Preoperative and postoperative care.....	1
Laboratory.....	1
Roentgenology.....	1
Urology.....	1

Table IV, the answer to Question D-1, was specifically asked as a check on Question A and merely reemphasizes that the great weight of opinion is in favor of teaching the principles of surgery and surgical diagnosis. Again also we see emphasized the teaching of trauma and sepsis which constitutes such a large share of the general practitioner's work.

TABLE V

*Do You Consider It Your Duty to Teach Practical
Operative Surgery?*

No.....	40
Yes, as far as surgical technic is concerned.....	12
Yes.....	6
Yes, as far as animal surgery is concerned.....	5
No, but assist at a certain number of operations..	1
Doubtful.....	1

Table V was worded so as to make the teachers take a definite stand on the teaching of operative surgery. Note that only a negligible percentage of teachers feel that they should teach practical operative surgery.

The final question, D-3, "Do you teach sufficiently well and do you have time and materials enough in your curriculum to satisfy yourself that you are covering carefully the following: (a) The care of trauma, including fractures; (b) the care of ordinary sepsis, and anesthesia", was asked to determine specifically the teaching of matters that are essential to the education of the general practitioner of medicine. The 51 answers were practically unanimous that they had both time and materials to cover thoroughly the teaching of trauma, including fractures, and sepsis. But there were many who agreed that anesthesia was poorly taught. Thirty professors felt that they had time and material to teach anesthesia, but 19 were definite in their opinion that they had neither time nor material, and three were doubtful whether with their set

up this was possible. This problem of anesthesia is, indeed, perhaps the most flagrant gap in the student's education, and it is a sad commentary that in America where such a great impetus was given to the art of anesthesia we should now neglect it. It also must have an unfortunate reflection on public opinion, for almost every doctor must from time to time, by the very fact of his degree and supposed learning, give an anesthetic, and if only to save our graduates embarrassment we should remedy this part of our teaching.

There are many forces, of course, which are acting to cut down instruction in anesthesia, largely its standardization 20 years ago to a few inhalation anesthetics and local infiltration anesthesia, which resulted in the advent of the nurse anesthetist. It was found that nurses could be easily taught the safe and proper use of the various inhalation anesthetics then in use and, as this cut down the cost of surgery both for hospitals and the public, this form of practice was popularized. Now, however, things are different. A great array of very valuable drugs, dealing with the art of anesthesia, have recently been introduced into the profession and the nurse anesthetist is now no longer competent to assay the value of or even practice the use of the many diverse drugs which have been proposed. It is quite proper, therefore, that at this time we take a step forward and try to fill this gap in the student's education by providing more efficient instruction in the art of anesthesia. We shall find ourselves hard pressed to do this, for only a few doctors go into this branch of medical practice and of those only a few are qualified to teach others.

SUMMARY

In a review of the present status of the undergraduate education of the surgeon in the United States, it is clear that all of our approved or Class A medical schools are well standardized in the general methods of teaching surgery. It is obvious that the chief stress is laid upon teaching the principles of surgery, surgical diagnosis, and giving to the students an opportunity to study, in the dispensary and at the bedside, a sufficient number of cases to acquaint them at first hand with the extent, the benefits, and the dangers of surgical therapy. It is obvious that there is great unanimity in keeping the education general, avoiding emphasis on the specialties, and that the curriculum as a whole is set up to ground the students in the essentials and to acquaint them specifically with methods of caring for trauma and sepsis. It is clear that the teaching of anesthesia is inadequate and should be remedied. It is particularly clear that the teachers of surgery do not think it is their duty, and indeed do not attempt to teach practical surgery to undergraduate medical students. The corollary to this is that the real education of the surgeon is a postgraduate affair.

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GRADUATE TEACHING OF SURGERY IN UNIVERSITY CLINICS

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GRADUATE teaching of surgery which has for its purpose the development of men qualified to assume the leadership in the practice of surgery in the various communities of the country and to continue the teaching of surgery in our medical schools is, in my opinion, the most important educational problem confronting the surgical profession. No matter which of the many important questions now perplexing us we subject to analysis, we come back eventually to graduate teaching of surgery as one important means of solving our surgical difficulties. It is a matter, then, which deserves our earnest consideration, especially at this time when dissatisfaction with medical practice seems widespread and profound changes in it appear possible.

Graduate teaching of surgery, in a real sense, may be said to have been inaugurated in this country by W. S. Halsted about 1900 at the Johns Hopkins Medical School and Hospital. In the annual address on medicine at Yale University published in 1904, he pointed out the need for advanced training in surgery in this country, emphasized the eagerness of young men to embrace this training and described a form of surgical education to equip a young man for teaching and practice. Its distinctive features were a long and continuous period of residence in a teaching hospital (up to ten years) in intimate contact with surgical teachers, large clinical material, laboratories, teaching and research and the development of independent work through the responsibility for the care both in the wards and the operating rooms of patients coming to the hospital. Halsted, therefore, developed a method of teaching surgery and, through experience, determined the duration and scope of a surgical education, which to him was necessary properly to equip a young man for a surgical career. The results of his educational efforts, in the form of a long list of men distinguished in teaching, practice and research must be well known to you.

In the space of 35 years since Halsted began his educational program, graduate teaching of surgery has gradually spread in one form or another throughout this country. Naturally the medical schools and particularly the university medical schools have taken the leadership in this educational growth and, as I shall presently indicate, some form of graduate instruction in surgery may now be obtained in 39 of the 59 medical schools of the country which I have studied. Gratifying as this development may be, it is obvious that it does not meet the present situation. The reports of teachers of surgery indicate, as I have repeatedly pointed out, that the number of men who each year seek opportunities for advanced work in surgery far exceeds the opportunities

available to them. The growing demand for better training in general surgery, the agitation regarding licensure to practice and the qualifications for admission to specialist organizations—all imply that facilities for advanced education in surgery should be increased. But before an increase in such facilities may properly be undertaken, it would seem important to know the status of graduate teaching of surgery in our medical schools as it exists today and to consider the opinions of those of experience as to what it should be.

Several years ago I began a study of graduate teaching of surgery in the medical schools of the United States and Canada. I sent out, with the cooperation of Dr. Fred Zappfe, a long questionnaire to the heads of the surgical departments of all the recognized medical schools and I wish to take this opportunity sincerely to thank those who were good enough to respond. I have assembled the data regarding the graduate teaching of surgery, as at present carried out, of 59 medical schools and in addition have obtained the opinions of their heads of departments regarding certain aspects of the subject which I think of importance. From the data assembled I shall present briefly: (A) The method, duration, scope and recognition of graduate instruction as it now exists in 59 of the recognized medical schools of the country and (B) the opinions of the heads of surgical departments of the same 59 medical schools as to the kind of graduate instruction they would give were it possible, regardless of what they are now giving.

(A) In a study of the method, duration, scope and recognition of graduate instruction it is found that the 59 medical schools or University Clinics fall more or less naturally into four groups. These are (1) a group of 20 medical schools which fail to offer any graduate instruction in surgery; a number which represents 33.9 per cent of the total number of schools of which I have data; (2) a group of six medical schools in which the period of graduate instruction is less than three years in duration; (3) a group of 18 medical schools in which the course of graduate instruction is from three to four years in duration; (4) a group of 15 medical schools in which the course of graduate instruction is a minimum of five years and may extend over a period of six, seven or eight years.

The data regarding Groups 2, 3 and 4 may be presented briefly as follows:

Group 2. (a) Number of schools included: six.

(b) Method of instruction: resident system.

(c) Duration of course in graduate instruction: less than three years.

(d) Educational requirements: graduation from a medical school, four; graduation from a medical school plus one year's internship, two.

(e) Instruction and experience in Surgical Pathology: none or very scanty, four; three months' experience, one; six months' experience, one.

(f) Instruction and experience in Surgical Research Laboratory: none or very little, six.

(g) Instruction and experience in Inhalation Anesthesia: none or very little in six.

(h) Instruction and experience in the Specialties of Surgery: instruction

and experience in Urology, Orthopedic Surgery and Gynecology is obtained in connection with the general surgical service in four schools; in a two months' service in each specialty in one school; and not acquired in one school at all.

(i) Instruction and experience in the treatment of Fractures: in one school there is no instruction or experience in the treatment of Fractures. In five schools such experience is gained on the general surgical service.

(j) Instruction and experience in General Surgery: in five schools this is obtained over a period of from six months to two years in the wards and operating rooms. In one school a short course only in Abdominal Surgery is offered.

(k) Instruction and experience in Operative Surgery: in all schools (six) this is obtained by assisting senior surgeons. In four schools the men in training are permitted to do a small number of operations under the direction and assistance of a senior surgeon. In five schools the men in training are not permitted to do any operations independently. In one school a resident is permitted to do about ten selected operations independently.

(l) Recognition of advanced work by Degree: one school grants a degree but the kind of degree is not stated; one school will grant a degree upon the basis of research work. Four schools do not grant a degree for advanced work in Surgery.

Group 3. (a) Number of Schools included: 18.

(b) Method of instruction: Resident or Fellowship system.

(c) Duration of course of graduate instruction: from three to four years. The course is three years in eight schools; may be more than three years in ten schools. In the latter group the course may extend over four years, and in some there is the possibility of extending the training of exceptional men to five years.

(d) Educational requirements for Admission: Graduation from a recognized medical school, six; graduation from medical school plus one year's internship, ten; plus two years' internship, two.

(e) Instruction and experience in Surgical Pathology: This is elective in one school; covers two months in one school; three months in three schools; four months in one school; and at least six months in 12 schools.

(f) Instruction and experience in Surgical Research Laboratory: in four schools this is omitted or optional; is very little in four; covers a period of three months in two; covers at least six months in six; and is stated to be more or less continuous over the period of training in two schools.

(g) Instruction and experience in Inhalation Anesthesia: very little or none in 18 schools.

(h) Instruction and experience in the Specialties of Surgery: instruction and experience is not obtained in one school; and not in gynecology in another. In 14 schools approximately three months are devoted to each specialty; in three schools experience is gained on the general service which covers these specialties.

(i) Instruction and experience in the treatment of Fractures: in 15 schools fractures are included under general surgery; in three schools instruction and experience is obtained in a period of from three to six months on a special fracture service.

(j) Instruction and experience in General Surgery: this covers from six months to three or more years depending upon the time devoted to laboratories and Specialties in Surgery. In general 50 per cent of the period of training of from one and one-half to two years is devoted to general surgery in the majority of schools.

(k) Instruction and experience in Operative Surgery: this is obtained by assisting senior men, by operating under the direction of instructors and, in some schools, by the independent performance of operations. In seven schools the men in training are never allowed to operate except under supervision; in 11 schools they are allowed to operate independently. The number of operations performed by the men in training varies in 11 different schools between 50 and 350 with the larger number predominating; in six schools the number of operations is not stated.

(l) Recognition of advanced work by Degree: An advanced Degree is not given for graduate work in Surgery in 10 schools; an M.S., B.Sc. or Ph.D. is given on the same basis of graduate work in other University Departments in four schools. Four schools did not answer the question.

Group 4. (a) Number of schools included: 15.

(b) Method of Instruction: Resident or Fellowship system.

(c) Duration of course of graduate instruction: a minimum of five years with extension in some to six, seven or eight or more years.

(d) Educational requirements for admission: graduation from a Class A medical school in four schools; graduation from a Class A medical school plus one year's internship or its equivalent in 11 schools.

(e) Instruction and experience in Surgical Pathology: this is limited to three months in two schools and extends over a period of six months to one year or more in 13 schools.

(f) Instruction and experience in Surgical Research Laboratory: this is omitted in one school; limited to two months in one school, occupies a period of three months in one school and covers a period of from six months to one year or more in 12 schools.

(g) Instruction and experience in Inhalation Anesthesia: this is very little or entirely omitted in 13 schools; of less than two months' duration in one school and of four months' duration in one school.

(h) Instruction and experience in the Specialties of Surgery: in Urology this is obtained in a three months' period in one school; and in a six months' period or longer in 14 schools. In Orthopedic Surgery this is omitted in one school, is covered in three months in one school and in six months or more in 13 schools. In Gynecology instruction and experience varies greatly. It is omitted in a number of schools and varies in others from one month to one year.

(i) Instruction and experience in the Treatment of Fractures: this is omitted in one school and is presumably adequate and fairly large and obtained on a general surgical service in 14 schools. In a few of the latter a special fracture service is organized on which the graduate student serves for a period of time.

(j) Instruction and experience in General Surgery: in all of the 15 schools a period of two to three years is spent in general surgery. In general this period averages 50 per cent of the total time devoted to the advanced course in Surgery.

(k) Instruction and experience in Operative Surgery: this is obtained by assisting senior men, by operating under the guidance of senior men and by operating independently. In all 15 schools the Residents in training are permitted to operate independently. The number of operations personally performed by the men varies between 350 and 1,000 or more, the average being over 500 in 10 schools; is fairly large but not accurately stated in five schools.

(l) Recognition of advanced work by Degree: in 12 schools a degree for advanced work in Surgery is not granted. In two schools an M.S. or Ph.D. is granted under the conditions which obtain for advanced degrees in other departments. In one school a degree may be obtained, but its acquisition is discouraged by the head of the department.

(B) While it seemed to me of great interest and importance to know what is being done in graduate teaching of surgery in our medical schools, it seemed of equal importance to know what opinions regarding graduate teaching the various heads of surgical departments have formed as a result of their experience with the type of graduate teaching they themselves are doing. The second part of my questionnaire, therefore, requested an expression of opinion of the method, duration, scope and recognition of a more or less ideal course of graduate instruction—one which each head of a surgical department would inaugurate if conditions were favorable. The large majority of the Professors of Surgery in institutions in which opportunities for advanced surgical training do not obtain failed to offer opinions, some frankly stating that their lack of experience did not permit them to do so. The opinions studied, therefore, come from those who actually have had experience with graduate teaching over a variable period of time. They may be summarized as follows.

(a) *Method of Instruction.*—Forty-three heads of departments expressed themselves in favor of the Resident system or its modification (Fellowship) as a method by means of which an advanced education in surgery may best be acquired; 16 heads of departments did not offer an opinion.

(b) *Duration of Period of Advanced Training.*—One head of a surgical department is of the opinion that a course less than three years in duration is sufficient. Five heads of departments are in favor of a three years' course of graduate instruction. Five heads of departments believe that a course should embrace a minimum of three years but should be sufficiently elastic to permit certain advanced students to spend five years in acquiring a surgical training.

Eighteen teachers of surgery express themselves in favor of a period of training covering a minimum of five years. Twelve teachers of surgery are of the opinion that a period of training in excess of five years is desirable and extend the period to six, seven, or eight years. Eighteen heads of departments of surgery did not express themselves. A summary of these opinions shows that 12 per cent of the surgical teachers favor a three years' course in graduate instruction, 12 per cent a three to five years' course and 75 per cent a five to six or seven years' course of instruction.

(c) *Scope of Instruction.*—The very large majority of surgical teachers favor a fairly comprehensive training in surgery including surgical pathology, surgical research, fractures, the surgical specialties of urology, orthopedic surgery, and gynecology and general surgery, including personal experience in operative surgery. The variations in opinion concern the period of time devoted to each subject rather than to the subjects which should be covered in the course. Very few teachers seem to be concerned over the lack of training and experience in the administration of inhalation anesthesia which now is almost universal in surgical clinics. Twenty-seven surgical teachers did not favor formal instruction of any kind, but a number approved of conferences and seminars. One surgical teacher favored formal instruction in fractures and regional surgery. Thirty-one teachers did not express themselves regarding the nature of the instruction.

(d) *Recognition of Advanced Work by Degree.*—Twenty-eight surgical teachers favored an advanced University degree of some kind in recognition of the satisfactory completion of advanced work in surgery. Two surgical teachers, while not expressing themselves as opposed to a degree, questioned its value. Ten surgical teachers are opposed to a degree or think it unnecessary. Nineteen surgical teachers did not express themselves. The degrees now granted or suggested include Master of Science in Surgery, Doctor of Science in Surgery, Bachelor of Science in Surgery and Doctor of Philosophy. It is clear that there is no consensus of opinion at present regarding the degree to be granted.

(e) *Approval of Advanced Teaching of Surgery in the Larger Qualified Hospitals Not Affiliated with Medical Colleges.*—Thirty surgical teachers were of the opinion that the larger qualified hospitals might successfully undertake advanced surgical teaching provided the surgical staffs of the hospitals were experienced teachers and laboratory and other facilities were adequate. Four surgical teachers doubted that it could be done and one was opposed to the idea. Twenty-four did not venture an opinion.

DISCUSSION

In an appraisal of an educational program one naturally considers it from several viewpoints: from the viewpoint of the duration and subject matter, from the viewpoint of the quality of the students who participate in it, the facilities available for its successful promotion and excellence and enthusiasm of the teaching staffs which conduct it and, finally, from the viewpoint of

one's personal ideal. In the preceding analysis I have considered graduate instruction in our medical schools only from the viewpoint of its method, duration and scope, leaving out of consideration the important matter of the quality of the instruction given. This I did not have the opportunity to investigate and what value the study may have is, I realize, seriously impaired by the omission. But since I know, not all, but a large number of the surgical teachers of the schools included in this report, I think it may be fairly stated that the large majority of them are greatly interested in graduate teaching and, considering the difficulties in many schools due to unsatisfactory hospital affiliations, lack of laboratory and research facilities, restrictions in budget and limitation in personnel, are doing it very well.

An analysis of the various groups of schools shows, I think, the trend in the development of an educational program in our medical schools. It is apparent that the Resident or Fellowship system as a teaching method has been accepted as the best which thus far has been devised; it is apparent, also, that the advisability of a fairly comprehensive training in surgery including general surgery and the specialties of urology, orthopedic surgery and gynecology is generally agreed upon. As the longer courses of graduate instruction are compared with the shorter, it is evident that longer periods of time are being devoted to clinical work in general surgery and its specialties; but more striking is the emphasis upon and the increasing amount of time given to surgical pathology and experimental research in surgery. Perhaps most striking in the longer courses is the emphasis placed upon individual responsibility as a means of developing character, surgical diagnosis, technic and judgment. The gradually increasing responsibilities placed upon the graduate student (Resident) for the diagnosis, pre- and postoperative care and operative treatment of the patients in the hospital are, in my opinion, one of the most outstanding features of the longer courses of graduate instruction.

To judge the adequacy of graduate instruction as it now obtains in our medical schools one may compare the course of instruction with the ideal one hopes to attain at its completion. The ideal may vary greatly in the minds of surgical teachers. To me, the ideal end product of a course of graduate instruction is a young man who has had a rather broad fundamental training in the sciences related to medicine and, after his graduation in medicine, a long, thorough and comprehensive training in surgical pathology, surgical diagnosis, pre- and postoperative treatment and operative surgery; who has acquired the technics of, and become imbued with the desire to pursue, research; who has gained experience in teaching and departmental organization; and who has learned to know the ethics of the profession. In short, he is one for whom, at the completion of his training, his surgical teacher is ready and eager to stand sponsor either as equipped for a teaching career or as fully qualified to practice surgery.

If it is agreed that this ideal is the objective of graduate teaching, it must be admitted that the courses of graduate instruction of three years or less now given in many of our medical schools are inadequate; for experience has

demonstrated that this ideal cannot be achieved in a short space of time. That it has been and can be achieved in a period of from five to eight years under able teachers has been amply proven. The interesting and, to me, significant result of the second part of my questionnaire is that the great majority of surgical teachers apparently visualize this ideal and realize the time required for its achievement; for as I have noted, 75 per cent of all heads of surgical departments of medical schools who have had experience with graduate teaching advocate a five to eight years' course of instruction.

SUMMARY

(1) Data upon the qualifications for admission to the method, duration, scope and recognition of graduate instruction of 59 recognized medical schools have been collected and studied. Data representing the opinions of teachers of surgery regarding graduate teaching also, have been collected and analyzed.

(2) Twenty of the 59 medical schools studied do not offer any kind of graduate instruction in surgery. This number represents 33.9 per cent of the total number of medical schools of which I have data and suggests the opportunities still possible of development in this direction.

(3) In the 39 medical schools which offer some form of graduate instruction, the qualifications for admission to advanced study are graduation from a recognized medical school in 14 and graduation from a Class A medical school plus an internship in a recognized hospital in 25.

(4) The Resident system, meaning by the term a period of residence in a teaching hospital in intimate contact with teachers, clinical material and laboratories, is almost universally used as a means whereby opportunities for acquiring an education in surgery are offered.

(5) The duration of courses of graduate instruction varies in our medical schools. Six schools offer a course less than three years in duration; 18, a course of three to four years in duration, of which the period is three years in eight and may be more than three years in ten; and 15 a course which is always five years in duration and frequently exceeds this period.

(6) The scope of instruction is usually fairly broad and informal in character. It includes general surgery and the specialties of urology, orthopedic surgery and gynecology. In the schools in which the shorter courses are given, training and experience in these subjects are necessarily limited as they are in the laboratories of surgical pathology and surgical research. Perhaps the striking differences between the shorter and longer courses are, in the latter, the increase in time given to clinical work in general surgery and its specialties, but particularly the time allotted to the laboratories of surgical pathology and surgical research and the emphasis placed upon individual responsibility for the care, including operative treatment, of patients as a means of developing character, surgical diagnosis, operative technic and surgical judgment.

(7) The recognition of advanced work in surgery by the faculties of University medical schools does not obtain in the majority. An advanced Uni-

versity degree is not granted in 26 of the 39 schools under consideration and probably not in four; may be granted in nine schools. In these, degrees granted may be a Master of Science in Surgery, Bachelor of Science in Surgery, Doctor of Science in Surgery or Doctor of Philosophy. That the trend of opinion is toward the granting of advanced degrees is indicated by the fact that 28 surgical teachers favor an advanced University degree in recognition of the satisfactory completion of graduate work in surgery, two are not opposed to it but question its value, and ten are opposed to it, or think it unnecessary. Nineteen surgical teachers did not offer an opinion.

(8) The study as a whole would seem to indicate that the opinion of teachers of surgery regarding graduate teaching is in the process of crystallization. There is agreement as to the method of instruction and its scope. There appears to be, as judged by the expressed opinion of teachers of surgery, a growing realization of the need of a more prolonged period of education for the purpose of producing a higher type of surgeon. The fact that 75 per cent of the teachers of surgery believe, as a result of their experience, that five or more years of instruction are desirable while only 38 per cent now give that period of instruction, is evidence of the trend in this direction.

(9) The study is not to be interpreted as an effort on the part of its author, toward standardization of graduate teaching in our medical schools; for he is opposed to this idea. Teachers of surgery either have concluded or, in time, will conclude that a high type of surgeon is the objective of graduate teaching and have determined or will determine the period of time necessary to produce him. Within this block of time, teachers of surgery should remain free to carry out their ideas of surgical education just as they should, within reason, allow their graduate students to follow their natural bents.

(10) The study shows that, while satisfactory progress has been made in the development of advanced education in surgery in our medical schools, there still are lacking sufficient opportunities to meet the demands of men seeking a higher career in surgery and to meet the needs of the country in respect to trained surgeons. It would appear that our immediate problem is to discover, if possible, ways to meet this situation, by encouraging all Grade A medical schools to adopt graduate teaching as a part of their educational program, by presenting the possibility of the larger, qualified and at present non-teaching hospitals participating in this educational effort, or by some other means.

OPPORTUNITIES FOR GRADUATE TEACHING OF SURGERY IN LARGER QUALIFIED HOSPITALS

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THE interest in the subject of graduate instruction in surgery is increasing year by year, as the demand for more thoroughly trained surgeons has increased in state and national organizations. Such specialties as obstetrics and gynecology, ophthalmology and otolaryngology, already have national organizations requiring several years of special training; and within the last year definite steps have been taken by the Advisory Board of Medical Specialties for the recognition of advanced training in general surgery. As a body of recognized and qualified surgeons we should consider the subject of graduate training in surgery, and should see to it that certain standards in this training be established. In addition we should be careful that the faults and penalties of standardization are not imposed upon us by outside organizations in the next few years.

Doctor Heuer has discussed the opportunities for graduate training in the University Clinic Hospitals where the tradition, training and purpose of the Surgical Service is not only the care of the patient, but also teaching and research. There are, however, a very large number of completely equipped and thoroughly qualified hospitals in all of our large cities where there is a splendid opportunity for carrying on graduate teaching in surgery of an advanced type, but in which no opportunity is offered and no effort made to supply an ever increasing demand for graduate work. By graduate work I mean training in actual clinical and operative work for surgeons who have completed their internship, but who desire to spend three to five years more of training before going into the practice of surgery. This does not apply to physicians who have had no surgical training, who have been in general practice and who for one reason or another desire to become surgeons in a period of a year or less.

A few of the postgraduate courses and fellowships offered in various parts of this country are in many ways carefully planned, and a review of the subjects of anatomy, physiology and pathology are adequately given; but they practically all lack the one essential, namely, the training in actual operative work in a graduated ascending scale, and in the giving of responsibility under supervision to the graduates taking such a course. The only place in which this type of training is given is in the hospital where the Resident or Fellowship system is in vogue, and where the scheme as outlined by Doctor Heuer has been in operation.

I wish to qualify the type of hospital and the character of training that are under discussion. Only thoroughly equipped hospitals, having (1) ade-

quate laboratory facilities, (2) free ward bed patients, (3) continuous services, and (4) recognized surgeons of real ability who are truly interested in teaching on the visiting staff, are considered as offering the opportunities for actual clinical and operative training. Such hospitals may or may not have medical school affiliations. If they have, so much the better. There are one or two large municipal hospitals in every large city and three or four others having large endowments with ample free bed services that could qualify for this type of training.

There are definite reasons why adequate opportunity for graduate training has not been offered by the qualified hospitals in this country up to the present time. This has to do with the history and tradition of the organization of the visiting staff and the internships in the hospitals in various parts of the country.

In the majority of the charity hospitals in the large cities the visiting staff on the surgical services for many years has been a fixed one, often arranged in four or six month services. In more recent years a Surgical Director has been appointed, with a large number of associate and assistant surgeons under him. As a rule the members of the visiting staff are in active practice, and in a number of the charity hospitals a considerable amount of the emergency work and the less major operating is done by a resident staff. If such resident surgeons are given the proper guidance and assistance their training is the type that fulfills the requirements of graduate teaching; for as a younger group, having had an internship and rotating through a period of three years of graduate training, they constitute an invaluable link between the internship and the permanently appointed but often frozen group of visiting surgeons.

In many hospitals, however, there is no intermediate group between the interns and the visiting staff. The interns, if given a large amount of operative work—as is the case in some cities, notably New York—are not experienced enough to benefit by it, and their term of service is too short to be of value to themselves or the surgical service.

In other hospitals, if the senior visiting surgeon is avid for operations and basks in the kudos of a large public operative clinic, the younger attending surgeons have to be content with the leftovers, and not many crumbs are left for any one of the grade of surgical resident or fellow.

In some cities a certain tradition has grown up which favors giving a large amount of the less major work to the house surgeon. In New York this has an interesting history. In the late '70's and early '80's, because of the lecture system and the lack of individual instruction in the medical schools, a system of quizzes developed which was designed originally to give individual students more detailed knowledge in anatomy and physiology, but which within a few years frankly became an extracurricular training class for hospital examinations. The men who stood high in a quiz were sure to get high rank in the hospital examinations at the end of their medical school course. It is interesting to note that William S. Halsted was one of the pioneers in quiz teaching at the College of Physicians and Surgeons, and at one time

before going to Baltimore he had some 75 men in his quiz. These quizzes accomplished a very much needed instruction at the time, but they subsequently created a very distinct prejudice against the Resident system in New York hospitals.

The competition for top quiz men on the part of the hospitals soon became keen, and it naturally resulted in more and more operative work being given to the good house surgeons as an inducement to attract the best quiz men. The younger visiting surgeons in giving away emergency and routine operations to the house surgeons were naturally more popular with the intern staff. A tradition was thus established which has had a distinctly bad effect in discouraging the development of surgical residents or surgical fellows in the charity hospitals of New York and other large cities. It does not require any great acumen to understand why a graduate group, intermediate between interns and junior visiting surgeons, is not popular when first introduced into a surgical service.

There is another reason why the idea of surgical residents or fellows is unpopular with many surgeons and in many hospitals. In the past, especially in some of the large university clinics, the surgical resident, during his indeterminate term of office, has been entirely too autocratic and domineering in his attitude towards all but his immediate chief; and in some instances he has antagonized both the visiting staff and interns alike against the whole Resident system.

There is a happy medium between the surgical staff with no intermediate group between interns and visiting staff, and the resident staff with an autocratic resident surgeon.

The surgical internship should be so arranged as to be a stepping stone for the able house surgeon to be advanced to an assistant resident or junior fellow. During the period of service as house surgeon the intern should be given a fair amount of the responsibility of the ward service and enough operative work under direct supervision of the visiting staff to determine his dexterity, his judgment, and his general fitness to continue in his surgical training as resident or fellow.

A group of three or four assistant residents or junior fellows, so chosen, may well spend a year in out-patient work in the mornings, with their afternoons free to work on some laboratory or clinical investigation in medical school or hospital. From this group the one best qualified should be advanced to a residency or senior fellowship, and for a period of two to three years should be given increasing operative work in major surgery, rotating through the main fields of extremity, thoracic and abdominal surgery, with subsequent training, if he desires it, in the specialties. This would mean a longer and higher curve of training than the typical saw tooth curve of an internship, and would provide a regular changing group of young, adequately trained surgeons intermediate between intern and visiting surgeon, stimulating investigative work and keeping both intern and visiting staff on their mettle.

It would do away to a large extent with the inertia of the sterile frozen

visiting staff, so common in our charity hospitals. This plan should not carry with it, however, the faults of some of the university clinics, where the major part of the operating as well as a good part of the teaching is done by a relatively inexperienced resident staff; for the plan as outlined insures a balanced division of the operative work between house surgeon, resident or senior fellow, and visiting surgeon, and demands that the assisting and teaching of the residents or fellows in major operative procedures be done by the visiting surgeons; also that the greater part of the instruction of undergraduates in the principles of surgery in university affiliated hospitals be done by the older visiting surgeons.

There are and there will continue to be strong objections to this plan on the part of the superintendents of hospitals because of the added expense of housing a group of four additional men on a surgical service. There are the natural objections of house surgeons and junior visiting surgeons to the proposal. But only such hospitals as have tried having a group of live, keen, carefully selected young surgeons receiving advanced training by rotating through the surgical service have any idea of the advantages to the hospital and to the great problem of meeting the steadily rising demand on the part of the public and the state registering boards for surgeons who are adequately trained and properly qualified not only in general surgery, but in the specialties as well.

More recently the definite steps taken by the Advisory Board for Medical Specialties indicate the conviction on the part of the various national societies that men should be qualified in general surgery just as they are in ophthalmology, otolaryngology, gynecology and obstetrics. The license to practice surgery has been carefully worked out in such countries as Denmark and Norway, and in the Canadian province of Alberta, where careful training over a long period of time is demanded as a prerequisite of the granting of a license to practice surgery.

The granting of a degree for advanced graduate work in surgery or in the surgical specialties is not an essential factor in the success of the plan as outlined. It is the quality and character of the training over a three to five year period that will determine the benefit to the graduate and to the hospital in which he gets his training. But the character of the training will definitely determine the demand for such training in the individual hospitals, and the rating of such hospitals by the qualifying boards.

If in teaching centers such hospitals have university affiliations the granting of a degree for a long term graduate training can be arranged advantageously, but it should be granted only to qualified candidates who have fulfilled all the requirements, including the submission of a thesis on work done during the three to five year period. If in the large cities several hospitals should offer such graduate training, it would be possible to conduct seminars in the several hospitals for all the graduates taking such training, so that they would see the work of more than one clinic and would have the advantage of an exchange of ideas. Combined clinics in "middle ground" diseases such as

chest, thyroid, spleen, gastro-intestinal or vascular disturbances or tumors, in which internists, surgeons, pathologists and radiotherapists study patients before and after such therapy as has been agreed upon is completed—such clinics offer the very finest type of instruction for graduate students in both medicine and surgery. We find at the Vanderbilt Clinic that the combined clinics are the most sought after and appreciated by our surgical fellows. In fact our senior fellows have had a very real part in developing these combined clinics to their present high standard of usefulness, and have kept the senior members of the staff on their mettle to keep up the pace set by the medical and surgical fellows working in these clinics.

SUMMARY

To sum up the essentials for the adequate training of the graduate in surgery over a three to five year period after internship:

(1) Hospitals having adequate laboratory facilities, ward services for charity patients and a staff of unselfish surgeons of recognized ability and character, who are interested in the advanced training of surgeons after the intern period.

(2) A graded scheme of instruction in preoperative, operative and post-operative care of patients with an increasing amount of responsibility and operative work, under supervision of the senior surgeons, over a period of three to five years.

(3) Seminar instruction in combined clinics in the out-patient departments of the several hospitals in the larger cities in which graduate training is being given. These seminars should be held for the combined groups of graduates in the several hospitals of the individual cities.

(4) The granting of a degree for qualified graduates after a period of three to five years of training is not an essential feature of the proposed scheme of graduate training. For hospitals having university affiliations there are advantages in granting a degree provided those receiving the degree are qualified by adequate examination, and provided they present a thesis as evidence of original work during the period of training. The degree should be rigidly reserved for properly qualified candidates. Its value will depend upon the quality and character of the work done in the hospital and university granting the degree.

The responsibility of the representative surgeons of this country to meet the ever increasing demand for more advanced training in operative surgery and in the care of surgical patients must be met not only by the surgeons working in university clinics, but also by the surgeons in the thoroughly qualified hospitals in the larger cities. The old type of postgraduate teaching from the benches of the amphitheater is a thing of the past. What is demanded and expected now is honest, careful, practical training of qualified men who desire to take a long term in their training of surgery.

In conclusion, we wish to emphasize that such graduate work as has been proposed in this paper cannot be and should not be standardized. A three

year experience in one hospital with one group might easily be more comprehensive than a five year training in another clinic. But there must be definite standards which should apply to candidates for the training and to those teaching in the clinic and hospital in which the training is given.

DISCUSSION.—DR. ARTHUR DEAN BEVAN (Chicago, Ill.).—The study and the teaching of surgery has been for most of us our life's work. There is only one way to learn surgery and that is from a master surgeon. This fact is as old as Hippocrates. In the Hippocratic Oath the surgeon pledges himself to teach the children of his master "Of Him who taught me the art."

The great schools of medicine and surgery have been founded by great physicians and surgeons: Hippocrates, Galen, Sydenham, Langenbeck, Claude Bernard, Virchow, Billroth, Osler; and may I mention two who are still with us today, William J. Mayo and Harvey Cushing. The apprentice learns from the master workman. The great assets of a medical school are the great teachers it possesses, not the buildings or the endowment.

The teaching and the study of surgery are very simple things. The eager pupil, after acquiring a good knowledge in the fundamental medical sciences, learns surgery by watching and assisting the master surgeon in his actual work of handling his patients, in the history taking, the examination of the patient, the laboratory work that is essential in the case, the treatment or operation which is indicated; this is done in the teaching clinic in the hospital and the dispensary.

In this teaching the essential scientific knowledge should be taught in the simplest possible way, in the most commonsense way, in the most judicial way. I have been much impressed by Sir Thomas Lewis' book on the heart. Here is a book written by a great scientific student, a man who has added much to this special field of knowledge by years of research, and yet he tells his story in such a simple, commonsense way that even a surgeon can understand. We who are teaching surgery can well take a lesson in teaching from this book.

In teaching surgery we must devote at least half our time to teaching of the anatomy, the physiology, the pathology and the general principles of surgery involved in the problem under discussion. I have found that, no matter how well trained the students have been in these daughter sciences of medicine before they come to us, that it is absolutely essential to review these underlying sciences in each surgical case presented in the clinic. This is the only way of mastering these fundamental sciences. Surgery should be taught in the medical school as a well balanced whole. The entire field of surgery should be taught by men well grounded in general surgery. There should be no independent courses taught by surgical specialists. Men who are broadly trained in general surgery and devoting most of their time, or all of their time, to some special field can be utilized in the teaching of special subjects, provided that it is made to fit into a well rounded and well balanced whole. It is not safe, however, to give these men the teaching control in these special fields because they attempt to teach their subjects as though they were making specialists of the undergraduate students and as though it was an independent subject and not as it should be taught, as a part of general surgery.

Possibly, I can make my conception of this subject clearer by outlining the plan which we have developed in our own work. The teaching clinics conducted by the Chief and his associates are the backbone of the surgical course. These clinics cover the entire field of surgery. The entire subject is divided into three parts: (1) The head, neck and thorax; (2) the abdomen; (3) the

extremities. Three months of each year are devoted to each of these divisions. In the study of the head, neck and thorax, the general surgeon giving the course asks the specialists in neurosurgery, oral surgery and thoracic surgery to give to the undergraduates a few special clinics, giving in a simple way a summary of these special fields; no attempt should be made to cover them completely. In the same way the course on general abdominal surgery should be supplemented by a specialist in genito-urinary surgery, and the course on the extremities be supplemented by a few clinics given by an orthopedic specialist.

The proper place to teach the surgical specialties is in the postgraduate work for those who are preparing themselves to enter such specialties. We have made a mistake in this country in splitting up general surgery into too many divisions. Before it is too late these subdivisions should be brought back into general surgery, at least as far as the teaching of undergraduates is concerned. This must be done in the interests of the science of medicine, the medical profession and the public.

Half baked commercial specialism is today a great menace both to the profession and the public; there should be no hesitation in pointing this out and in correcting it. Many of these so called specialists are no more fit to take charge of important clinical problems than are laboratory technicians. Outside of their very limited field they are lost and their patients suffer. The only safe specialist in surgery is the man who is first of all well trained in general surgery, who then develops into a specialist by devoting special work to some particular field.

Every general surgeon should cultivate some special field in surgery so thoroughly that he becomes a recognized authority in that field. If later he is forced to limit his work, all well and good. Such men are the best specialists. As an example, in each well organized surgical department, there should be one or more men doing outstanding work in bone and joint, rectal and colon, genito-urinary, thoracic, neurologic, plastic and abdominal surgery. This is the only way of developing sound and scientific surgical specialists. The young men who receive their entire surgical training in the clinic of a specialist whose work is limited to a narrow field of the patient's anatomy, a single organ or group of organs, are greatly handicapped. They become, as a rule, mere technicians in that narrow field; they do not see beyond it; they are often a menace to the patients who fall into their hands.

Medical students must receive instruction from men who are thoroughly trained to give it. They must be taught as a successful coach handles a football team. The conception that you can give a medical student a cadaver and a book and tell him to learn anatomy, or that you can assign him a patient, give him a book and a blank history sheet, and tell him to learn clinical medicine is the daydream of instructors in medical schools who have learned their medicine as salaried teachers in biologic laboratories and not as clinicians whose lives have been spent largely on the firing line of practice with patients and in teaching clinical medicine.

Modern surgery is the application of anatomy, physiology, pharmacology and pathology to the study of the etiology, diagnosis and treatment of surgical conditions. It is well, early in the student's clinical work, to saturate him with the conception that he must for the rest of his life study the sciences of anatomy, physiology and pathology, as well as the sciences of diagnosis and treatment. The value of experience with a large group of well studied and well handled cases can not be overestimated; such experience becomes the surgeon's greatest asset.

The surgeon must be primarily a well trained practitioner of medicine. The

great surgical teachers have always emphasized that fact—Billroth, Bier, Senn and Cushing. The modern surgeon who is not thoroughly trained in general medical diagnosis and therapy and who does not keep abreast with the increasing knowledge in general medicine and who depends on his medical colleagues for the diagnosis in his cases degenerates often into a technician. The modern surgeon must be quite as well prepared to make as complete and exhaustive examination and as definite a diagnosis and differential diagnosis of the cases that come to him as his medical colleagues. That is true, and most important, because the majority of the cases seen by the surgeon are not operative cases at all.

Harvey Cushing is a good example of a well trained general surgeon, gradually developing a surgical specialty to a point where he becomes a great authority in it and at the same time he continues his contact with general medical knowledge until he becomes not only a neurosurgeon, but also a broadly trained physician and a recognized authority in neurology.

May I apply these thoughts to the future development of the American Surgical Association and to the development of the men who compose it? Let us make of the American Surgical Association a Society which will cover in its work and membership the entire field of surgery; let us take into the American Surgical Association the men who have had a broad training in general surgery and who have become leaders in all the special fields of surgery; let every member of the Society develop himself primarily as a general surgeon and at the same time cultivate some special field until he becomes a recognized master of that field; let every member realize that primarily he is a physician and keep in training so that he remains a great physician; let us recognize and emphasize the fact that surgery is a profession and not a trade or a business.

The surgeon occupies a most important place in the community. He is often the court of last resort. The health and the life of the patient are often in his hands and depend on his judicial decision and efficient management. We must see to it that the men who enter the ranks of the qualified surgeons of this country are not only men of scientific training, but, what is equally or more important, that they are men of character, culture and refinement; men who accept a high code of morals which controls them in their lives and professional work; men who never commercialize their profession; men who accept the spirit of the Hippocratic Oath and the code of ethics; men who practice the Golden Rule.

The intern year should be regarded as part of the undergraduate course. The intern should not be permitted to do independent operating in any hospital. He should be still regarded as an undergraduate student, and I think the proper development of an organization in surgery should be carried out not from the time period, but just as it actually has been carried out in the best teaching clinics of the world. After his intern year the young man training to be a surgeon should become house surgeon, then assistant and later associate in the hospital and in the clinic.

It is not a question of being there three years or five years. The training of a surgeon is the work of a lifetime; it means that the young man who aspires to become a teacher of surgery must mount one step after the other—intern, house surgeon, assistant instructor, associate instructor, instructor, assistant professor, associate, and finally Professor of Surgery.

We owe a great debt to the gentlemen who have prepared this discussion, but I think we should simplify very much the entire course.

DR. DAVID CHEEVER (Boston, Mass.).—I want to second what Doctor

Bevan has said about the obligation we are under to these three enthusiastic and able men who have presented such excellent reviews of this subject. Really, much the easiest thing for me to do would be simply to say Amen to what they have said, with which I agree almost entirely.

I am entirely in accord with Doctor Cutler's characterization of the principles of surgery, the institutes of surgery, as the study of prevention of pain, hemorrhage and sepsis, and I would add to that perhaps the prevention of deformity and promotion of repair. I am strongly in favor, also, of his insistence, as are Doctor Whipple and Doctor Heuer, on the study of anesthesia in the undergraduate curriculum. I think it is absolutely necessary. I think anatomy ought to be taught by men who know the significance of anatomy, not by Doctors of Philosophy who have never seen a sick patient.

I should like also to say a word about pedagogy. I do not think we pay enough attention in our undergraduate work to the encouragement of teachers who are good teachers. I think that pedagogy is a very important thing; whether it can be learned or not, I do not know. Certainly, some men tend to be born with it and some men, no doubt, develop it. To my mind, it is better that a first class man should lecture or teach 50 men than that a second class man should teach ten men.

Of course, the resident system is perhaps the particular point which is novel to some of us and I rather think we have to shed a tear upon the bier, as it were, of the old-fashioned intern system. Yet, as I look around at this group, I see some of the most prominent surgeons who were developed in that system and developed themselves from that system, and I think that the old internship such as it existed at the Massachusetts General Hospital in the old days, of two years, developed a very splendid type of man who was able, as I say, to develop himself as far as he wanted from that point.

I think it is no, or at least but a slight, disparagement, but an inevitable, regrettable feature of the too highly developed residence system that the old intern system has been somewhat emasculated.

We are building a pyramid which consists of different strata, and we are trying to train a man to reach the top. Of course, all success in life is a pyramid. Ultimately, we find the successful man at the top, but our education under the residence system tends to make men feel that they have to go through these successive steps; those of the undergraduate, the intern, the assistant resident and resident and super-resident, *etc.*

We are training a group of men who are so highly trained they get ideas that they must attain to that pinnacle before they stop being educated, and it seems to me we ought to encourage some of those men, certainly a group of them. There are not places enough for them all to reach the top and it is very painful to see these ambitious young men feeling they have to reach that ultimate pinnacle of surgical education before they can start in practice. Some of those men, I think, ought to be counseled to drop off at various points and enter the rough and tumble of practice. Just how it can be done, I do not know.

One sentence of Doctor Heuer's paper might be considered a little bit cynically. He speaks of the ideally trained surgeon as a young man who has fulfilled the postulates which he describes, and all of which are highly desirable. A simple computation will reveal the fact that the young man is nearly 35 years of age when he has fulfilled those postulates. He has reached at least half of the psalmist's three score years and ten, and he has reached more than the half of the average age at which he will be forced to retire from his surgical work.

He ought, I suppose, to take Osler's advice to the young man to put his

passions upon ice and wait, but perhaps he might after all have the normal instincts of mankind, to establish a family. We might again turn to Osler and say that life ends at 40.

I am rather inclined still to turn to another distinguished man and say that perhaps at 40, having attained the perfection of surgical education, he will then belong to that sterile, frozen group of visiting surgeons described by Doctor Whipple. There is no such thing as too much education in surgery and I am in favor of the highest education we can get, but let us use common sense.

DR. THOMAS G. ORR (Kansas City, Kans.)—Our aim in this discussion is to formulate in our own minds the practical needs of surgery and present ways and means to improve surgery in general and especially in this country. While the thought must assuredly come before the act, theorizing and preaching without practical application will accomplish little. The crying need for more surgeons and fewer operators must be evident to all.

Without a revolutionary change in our medical practice laws the only hope for better surgery in the United States is proper education of young surgeons and education of the public that only specially trained surgeons are qualified to do major surgery. Surgery is being taken to the patient more and more by the construction of small community and private hospitals. Patients prefer to be operated upon near their homes and are likely to accept service in inadequately equipped hospitals for this reason. I have known civic pride and a sense of civic duty to influence patients to remain in their own community hospital for surgical treatment. The only answer to this situation is to place better trained young surgeons with better trained surgical nursing supervisors in the smaller hospitals throughout the country.

After listening to this symposium one may conclude that a minimum of three years postgraduate surgical training in addition to the intern year is necessary before a young surgeon can render adequate service to the public. It is further concluded that additional years of training are desirable, especially if men are being trained for teaching and investigative work. In a service of three to eight years the graduate student in surgery is brought in daily contact with all phases of training necessary to equip him to do operative surgery safely. In addition to learning diagnosis, the indications for surgery, surgical pathology and physiology, pre- and postoperative treatment and operative treatment and operative technic, he cannot fail to acquire to some extent the spirit of investigation, and, by no means least, a sense of surgical honor. Equipped with such training a man would rarely fail to raise the standard of surgery in his community.

I do not believe that there is any justifiable complaint against the quality of surgery being done in university and private clinics where years of postgraduate work are offered. The urgent need of improvement is in the general private practice of surgery where now exist only a sprinkling of surgeons and a deluge of operators.

I question if we, as surgical teachers, are making our influence felt as it should be felt for the betterment of surgery. In addition to thorough training perhaps more thought should be given to the placing of competent young general surgeons in strategic positions in our own states and communities. This to my mind is one of the first steps toward better surgery in private practice. Young men who have lived in an atmosphere of surgical respectability from three to eight years will undoubtedly discourage not only inefficiency but the other two major evils, useless operations and fee splitting. Some plan by which the stamp of approval by certification can be placed upon

qualified young surgeons, which the general profession and public will recognize, seems to be indicated at this time.

DR. WILLIAM E. GALLIE (Toronto, Canada).—The introduction of a symposium on the Education of the Surgeon into our program indicates that at last we are alive to the seriousness of the situation in regard to the practice of surgery as it exists throughout this country.

Doctor Cutler has shown that our medical schools make no pretense toward teaching this practice of surgery to undergraduates. Yet each school grants a degree which publicly declares that the graduate is qualified to practice medicine and surgery, and some schools even go so far as to grant, along with the M.D., this special degree of C.M. The result is that the great mass of the surgery is being done by men who have been inadequately trained.

To overcome this Doctor Heuer and Doctor Whipple suggest that proper opportunities be provided in our medical schools and large non-teaching hospitals for postgraduate training of surgeons. This is an admirable suggestion but it will be ineffective or only very slowly effective unless the general public and more particularly the family practitioner is brought to understand that special surgical training is essential. Restrictive legislation of some sort must be introduced which will prevent inadequately trained men from performing major operations. Doctor Heuer's plan of postgraduate teaching appears to me to be excellent for the young surgeon who proposes to become a teacher of surgery. The prolonged period of training suggested, however, seems to me to be altogether too long for preparation for ordinary practice. There should be two courses provided, one for the teacher, which includes a prolonged residence in a hospital, opportunities for surgical research and perhaps a tour abroad, and one for the ordinary practitioner of surgery.

Both Doctor Heuer and Doctor Whipple have indicated the solution of the problem of the proper education of the surgeon when they suggest that our large hospitals constitute themselves as postgraduate schools whose students are the surgical interns. It seems to me that if we could get away from the idea that the surgical intern is a servant who does the daily work of the hospital for a year or two and then disappears, and substitutes for it the notion that he is a graduate student who has come to learn to be a surgeon, a long step will have been taken in the right direction. This would mean that when the intern is appointed it will not be for a year or more in somebody's service, but it will mean that after due consideration and adequate preparation he is committed to a surgical career and has been admitted to a balanced course which includes sufficient time in clinical medicine, surgical pathology, general surgery, gynecology, urology, orthopedics, *etc.*, and that when he departs from the hospital it will be with the guarantee of his teachers that he is qualified to practice surgery.

DR. DEAN LEWIS (Baltimore, Md.).—I have been greatly interested in Doctor Cutler's presentation of the subject of undergraduate teaching—the time to be devoted to each subject, the arrangement of the material and the advantages and disadvantages of lectures, which have been frequently discussed during the past few years.

The most important matter of all is the student material. If the students are mentally equipped and are of the right kind, it matters little about the rest. I have talked with surgical teachers frequently about the quality of the student body. It seems to be quite generally conceded that in a class of 70, from 15 to 20 students will be of superior quality. No teaching is required when these are considered. They require some direction but will work independently. They are hampered rather than helped by too much teaching.

In this class will be from five to ten who do not do well. These students, often apparently trying their best, do not seem suited for the study of medicine. I believe that these students should be kindly advised at the end of the first year that they should discontinue the study of medicine. A student who might have been saved may be dropped at times but the number so lost to medicine will be small.

Between the first and the last groups fall the large number who have to be watched carefully, guided along their course and stimulated to increased endeavor.

In educating this group, some discipline must be employed. There is a tendency in modern education for the student to neglect the subjects which are difficult. At times he is abetted in this by the instructor, but I believe the student should be stimulated to overcome such difficulties, for such training gives confidence and a will to do.

The quality of the material is the most important thing in maintaining a high quality of medical care and simplifying medical teaching.

DR. EUGENE H. POOL (New York).—I have been very much interested in the problem of graduate surgical teaching for some years, and have been in a position to watch, as an impartial observer, these two methods in operation. I think the problem has not yet been solved. Yet Doctor Whipple's method has much in it that appeals to me.

His plan continues the old method of the intern. Under it a man who goes on as an intern gets something worthwhile throughout the whole period of two years, including operative training at the end. Therefore no time is wasted. A selected group continue as fellows. The only objection to the system is that not enough men can have the opportunity of a fellowship.

The other method, based on residents, produces from a large center two trained men every 18 months. That is not a drop in the bucket towards supplying the needs for surgeons through the country. Moreover, as our President stated, "the surgeon needs skill and judgment," but the greater of these is judgment, and the five years cannot give that.

The residents become skilful technicians, but at what price? A number of aspirants start. At the end of one year a considerable proportion are lopped off. This is unjust, and not economical, for these men have wasted a year, as far as surgical training goes. A number more are dropped off at the end of two years, again without surgical training, and again some, I believe, at the end of three years.

And what is the method of progress towards a Residency? Such is the nature of the competition that to get upstairs one must kick his colleague downstairs. One must play up to the men who have the appointments to make. This is not a character builder.

Doctor Cutler, I think, omitted only one thing in his admirable summary of undergraduate teaching, and that is the importance, to which Doctor Cheever has referred, of personal contacts. Who of us is not better for and does not revere the memories of close contacts with our Oslers, Halsteds, Bulls and McBurneys? The undergraduate now, I think, fails to get this stimulus and inspiration.

DR. JOHN S. RODMAN (Philadelphia, Pa.).—It does not seem to me to matter which method, of those which have been discussed, is finally chosen of educating surgeons. I think most of us will agree that Doctor Heuer's way is an excellent one, but I am afraid in a country of 130,000,000 people, the facilities are not going to keep up with the needs in that respect, and

that most of us are going to have to see surgeons grow up by the apprenticeship system, which I think most of the members of this Association have done.

If that is the case, then it seems to me the most essential thing that we have to have is some sort of a certifying body that will honestly certify to one's qualifications to practice surgery.

Doctor Whipple spoke of the Advisory Board of Medical Specialists and as a member of that Board I have been very much concerned and interested in the development of a standard for qualification that all the specialty boards now can follow.

I do not know whether or not the members of this Association know that there are now some seven actually organized and operating qualifying boards in certain specialties; more limited fields of specialization, of course, than general surgery, such as ophthalmology, otolaryngology, obstetrics and gynecology, *etc.*

I have had an opportunity to attend some of the examinations conducted by the ophthalmologists and otolaryngologists, and know that they are making a very determined effort to honestly qualify men in their special fields and to make them demonstrate that qualification before they are given a certificate to prove they are so qualified.

I realize for the general surgical field, of course, that to establish a qualifying board is a much more complicated matter. Whether it is of particular concern to this body or not, I am not sure, but I think we should at least take an interest in it. I think that some suggestion as to how this shall be done is going to come from other surgical organizations of the country. Perhaps the Surgical Section of the American Medical Association, perhaps the American College of Surgeons might consider this matter. I hope this Association, which we all here believe is the representative body of the United States, through a representative, if there be a Board in general surgery finally created, will have something to say about what qualifications may be set up for the general run of surgeons who are going to have to supply the needs of the country, admitting that those who will qualify through Doctor Heuers' method will be among the leaders of the profession.

DR. EVARTS A. GRAHAM (St. Louis, Mo.).—I think this is a momentous occasion for the American Surgical Association. Doctor Bevan started the ball rolling in this Association by calling attention in a very forceful way to many of the matters which have been brought up this morning.

I have been also particularly pleased with the remarks of our President and with the three papers. My principal reason for rising to take part in the discussion is to express my hope that now something will be done about the whole matter. The remarks made this morning, although excellent, are really only a continuation of the discussion that has been going on for many years among those of us who are teachers of surgery. Yet nothing has ever come of it in regard to the most important matter of establishing proper standards of qualification of those permitted to practice surgery.

There are essentially three organizations that might be interested, as Doctor Rodman has mentioned: The American Medical Association with its Surgical Section; the American College of Surgeons; and this organization, which very largely is composed of the teachers of surgery. It seems to me it is a very proper function of this organization, which very largely is composed of teachers of surgery, to carry on the interest in this work.

I feel that the American College of Surgeons' interests lie in perhaps a slightly different direction. At least, they have not shown much tendency to

interest themselves actually in the education of the surgeon, and, therefore, I am compelled to assume that probably their interests lie in other directions.

We, however, are a group of teachers of surgery and it seems to me that it is our duty and responsibility to take an active part in doing something about the training of the surgeon. I intend, therefore, Mr. President, at the end of my remarks to propose a motion unless I shall be out of order. But before I come to that motion, I should like to say that I am struck by the fact that there are certain serious defects in our approach to this problem which have not been touched upon.

Every speaker has mentioned the unsatisfactory state of affairs which permits a medical student after licensure by the state, to go out and perform any sort of operation which he wishes to undertake. All have mentioned also the fact that students nowadays go into a hospital for an internship, get exposed a little to surgery, and scatter to the four corners of the compass to carry out what they have learned.

Aren't these two factors chiefly responsible, gentlemen, for the large amount of poor surgery that is being done all over the country? Is there any good reason that can be offered for assuming that a man who has just graduated in the lower ten in his class, we will say, one of those to whom Doctor Lewis referred, has any right to practice surgery merely because he has had an internship which has exposed him perhaps to six or eight weeks of surgery? As a matter of fact is it not possible that such an internship may be a source of more harm than good? Is not an enthusiastic young man likely to overestimate the value of such a training and to develop a false sense of security, especially when such a rotating internship is acceptable to the American College of Surgeons, is apparently recommended by the American Medical Association, and is given an official recognition as a satisfactory sort of training by several state boards of health?

These are very fundamental defects. It seems to me that an examination into this whole question cannot possibly exclude an inquiry into what constitutes a suitable internship as a preliminary basis for a further surgical training. Is it not time to state frankly that an internship which permits an experience of only two or three months in surgery is not suitable and not acceptable?

I shall, therefore, Mr. President, propose that you, sir, appoint a standing committee of this Association to report next year at our meeting on a continuance of study of the question of the proper qualifications of a surgeon, in order that something may be done about it, instead of merely a reiteration of discussion.

DR. ROY D. McCLURE (Detroit, Mich.).—We have recently made a study in Michigan for the State Medical Society of the necessity for postgraduate teaching in Michigan. I would like to bring to your attention this postgraduate medical education pamphlet, published by the Michigan State Medical Society last year, reporting this study. We sent out examination questions to 1,000 doctors and had a large number voluntarily answered, giving us a fair idea of the present state of knowledge of students of the classes of 1910, 1920 and 1930. In this way we got some idea of the necessity for further postgraduate education.

As to the training of a surgeon, there can be no doubt there is great need for more better trained surgeons, not more surgeons but more surgeons who have had broader training. Anyone who has gone into the study of appendicitis mortality alone within recent years is simply appalled at the difference in postoperative death rates in the different hospitals. I know of one hospital

where the death rate is $16\frac{1}{2}$ per cent, as compared to 4 to 6 per cent in relatively nearby hospitals. This comes about because every man operates for appendicitis regardless of the fact that he has had no adequate training for practicing surgery. Until this state of affairs is corrected we cannot expect improvement.

I feel, as Doctor Whipple said, we should not have standards of surgery forced upon us by legislation but corrective measures should come from within, and we, ourselves, should take the first step to improve the surgeon by providing five year training periods in adequately staffed hospitals. This will, of course, necessitate the coöperation and reorganization of many non-teaching hospitals, but I believe with the proper approach that this coöperation can be obtained and that it will lead to great benefit to the surgical staff as well as to the hospital.

DR. HUGH CABOT (Rochester, Minn.).—We hear from the seats of the alleged-to-be-mighty that there are too many specialists. It has even gotten into the papers. This statement seems to me so violently untrue that I venture to state the case in opposition.

There are not too many specialists in any field. There are altogether too many alleged specialists, people whose only evidence for specialization is their willingness to admit it.

If we should today set up a standard such as that proposed by Doctor Heuer, we should, I believe, be entirely unable to educate in any such way the number of surgeons which this country really requires. I think the crux of this matter is that there are today available, as Doctor Whipple has suggested, hospital organizations which can be used, if certain alterations are made, for satisfactory graduate education. They are not now being used. If we should by fiat decide that nobody should be allowed to practice surgery who had not had what we believe to be an adequate training such as proposed by Doctor Heuer and Doctor Whipple, we should be utterly unable to train those people in a satisfactory way.

We should like to believe that we could depend upon university organizations and upon the affiliated hospitals. Of course this is quite out of the question. We must draw into this picture a lot of hospitals now not doing proper teaching, not much concerned with anything more than the sending forth of alleged surgeons who lack proper qualifications and who must learn their surgery largely by trial and error.

I believe that this body probably could do more than any other to crystallize opinion in that direction, and lead toward the setting up of the proper organizations for teaching. They do not today exist, and we are required to see that they do exist before we lay down fiats as to what ought to be done.

I am interested in the awarding of advance degrees. I think them very desirable, but certainly they cannot be required. They do, however, tend to bring the whole problem under the purview of the university, where I think education in all fields ultimately belongs. I believe we should, as far as possible, encourage the men who are taking five or more years in preparation to become candidates for a degree where their affiliations are such that it is possible. That we cannot force it is obvious, but I believe we should encourage it. I think, in fact, we have not encouraged it sufficiently.

The crux of what I want to say is that we now have a restless mass of potential instructors perfectly capable of teaching surgeons as we think they ought to be taught. They are not organized, and I think we can do a good deal to help in their organization.

HIPPOCRATIC SURGERY

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IT is an interesting consideration regarding the continuity of medical thought, and perhaps for us a fortunate one, that of the two medical writers on Greek medicine, the one, Hippocrates, gives us an epitome of medical and surgical science at the very height of the ancient Greek civilization, and the other, Galen, sums it up at the end, within a few centuries of the fall of the Roman empire. In literature, art, and science, after Hippocrates began the gradual decline which, arrested though it was by many brilliant interruptions, finally ended in the chaos of the early Middle Ages; but in medicine we may say that, once established on the principles of humanity and common sense which Hippocrates established, its progress was sure and steady. Yet Galen summed it all up in his voluminous, controversial, often difficult and exasperating, but after all, brilliant, keen, and invaluable summary. During the 600 years between Hippocrates and Galen, there stand out the names of many real contributors to the science and art of medicine. Praxagoras of the school of Cos, Erasistratus and Herophilus, the anatomists of the school of Alexandria, who were the first to systematically dissect the human body, and contributed so much to our knowledge of the circulation and of the nervous system, and many others who were born, worked, and died in the interval between Hippocrates and Galen. Their writings have gone from the face of the earth, and all we know of them comes from the synopsis and quotations made by the great Galen. In spite of all his faults, we cannot but be thankful for his life, his work, even his contentious spirit, which led him in his argumentative style to quote so freely, in order to compare or refute their statements, from authors whose works have been blotted out by the hand of time.

Hippocrates, the great, the admirable, the divine, as Galen repeatedly calls him, looms in the skyline of the distant past; like a mountain, half hidden by mists and clouds, we recognize his greatness, we know little of his life. But apparently he never signed his treatises, and we have in memory of him three large volumes, some of them written with a lofty moral purpose, like the oath, and some of them showing his greatness, because pervaded with that common sense, which as Galen shrewdly remarks, is in spite of its name so rare that few people manifest it in the affairs of daily life.

It was the custom in his day to indulge in short and pithy sayings called "aphorisms," or in modern lingo "wise cracks," as shown by the reputation rightly or wrongly won by the "seven wise men" of ancient Greece by just such sayings. We have a book of several hundred of them, a credit to the great Hippocrates, beginning with the famous "Art is Long, Life is

Short," *etc.*, which is the best of all, and ending with its close rival, "What medicine will not cure, the knife will cure; what the knife will not cure, the cautery will cure; what the cautery will not cure, may be considered incurable." The long list between these two contains many which it is hard to believe were not interpolated by subsequent writers and commentators. Certain of Hippocrates' works, Prognosis, Diet in Acute Disease, Fractures, Dislocations, *etc.*, are written with a common sense and authority that mark them as the works of a truly great master. Others were plainly written by writers belonging to different schools of medicine though perhaps some of them were the pupils and successors of the great Hippocrates. Jones, who translated his works for the Loeb Edition, regards them as a part of the library of the medical school at Cos. The principal treatises are available in adequate translation and comment by Adams, Littré and others.

In general, if you compare the works of ancient medical authors on surgery with those on medicine, the former are characterized by greater clearness and lucidity. In surgery the problems presented are immediate and urgent, and require above all common sense and mechanical skill, swiftness, and coöperation between the hand and brain, and results for better and worse were, and had to be, quickly evident. What were they to do for the so called medical cases? Watch their course, care for the diet, and, as Hippocrates said, assist nature in her efforts to cure the patient. Having no chemistry, is it any wonder that they employed that great complex of philosophy, imagination and astrology called the doctrine of the humors, to explain the ills to which human flesh is heir? They had to have something, and they argued for this system so convincingly that everyone believed them for 2,000 years. And occasionally Galen argues so well for it that I almost believe him myself. I certainly find it as clear as modern medical chemistry, which, after all, may in a thousand years or so be on the top shelf with the works of Galen.

Since they had to do surgery, and the mechanics of surgery are so simple as compared with the chemistry of medicine, it is interesting to compare some of their surgical procedures with the present day. I am going to try to give you a brief account of what they thought about surgery, not included in the translations of the great works which you may read in the excellent translations of Adams and of Jones, but some of the minor treatises.

I am going to begin not with surgery, but with an account of the first experiment on an animal that I have found in literature. As all the writings of the Hippocratic collection may be dated not later than the fourth century, it may be dated no later than that. Now you should remember that the writings of the early poets were taken seriously by the ancient Greeks. Their old and new Testament may be said to have been the works of Homer or Hesiod, with their fantastic description of the gods and of natural phenomena. Now an early poet, Alcaeus of Lesbos, had written a poem in the dog days beginning, "Moisten your lungs with wine, for the dog star

risers again," for which reason or some other the ancients and even Plato concluded that the fluid nourishment went down the windpipe, and in some mysterious manner tunneled from the lungs to the bladder, where the surplus was eliminated, while only the solid food went down the esophagus into the stomach. Then someone discovered the epiglottis, which would plainly prevent the liquid getting into the trachea. However, the poet and the philosopher could not be quite wrong, they said, enough fluid must get under the epiglottis to properly moisten the lungs. It was to prove this that the experiment under discussion was advised. It occurs as a digression in the quaint treatise on "The Heart." I give it in as close an approximation as I can make to the writer's own words.

HIPPOCRATES DE CORDI (*Kuhn, vol. 1, p. 485*).—"The heart is pyramidal in shape, in color quite red. It is surrounded by a smooth capsule. In the capsule is a little fluid resembling urine, so that evidently the heart moves about inside this capsule. The reason for this is that the heart, with this protection, may be unimpeded in health and growth. It has just enough moisture to prevent it from becoming overheated. This fluid the heart absorbs and turns into serum. It takes it in and expends it continuously, receiving first from the lungs the fluid which we drink. The most of the fluid we drink goes into the stomach, because the esophagus is like a funnel and receives the most of the fluid, and the food ingested. Some of the fluid gets into the pharynx, being sucked in as from a nipple, about as much as can get in without being noticed as the main stream goes by. For the epiglottis is a tightly fitting cover and will not let in any more fluid than this. This may be proved if you will dye some water blue or red, and give it to a thirsty animal to drink, preferably to a hog. For this animal is neither a lover of beauty, nor neat in its habits. Then cut its throat while it is still drinking, and you will find this stained by the colored fluid. This operation, however, cannot be properly performed by everybody. There is no doubt about the fluid, then, that the human windpipe takes in some of it. But, you may answer, how is it that if a lot of fluid gets in it produces severe coughing and choking. For this reason, I reply, it is carried in the opposite direction to the expired air. For the little fluid that gets through the crack under the epiglottis does not interfere with the expiration of the air, but runs along the inner wall of the trachea, so that the moisture smooths the way for the passage of the air. This moisture is drawn out from the lung in turn, together with the expired air. The air, which is a means of producing health, the lung has to expel by the same route by which it took it in. Some of the moisture it absorbs into its enveloping membrane (the pleura) and some it allows to escape with the air. In the same way the palate separates the air from the moisture during expiration. The air has to be expired for the excellent reason that these things are not a form of nourishment suited to human nature. For how can raw wind and water nourish a man? No, they would be more likely to increase any disease already present. But to return to our description of the heart."

I have a great liking, as far as I can, to find out exactly what the ancient writers said on surgical subjects. Comment and summary are good, but let us see what they actually said. In a book entitled "Diseases" in the Hippocratic collection I found the following description of an operation for

empyema, which throws much light on the ancient methods of recognizing the presence of pus in the pleura and getting rid of it when found. It is a part of a discussion of abscess in the lungs and pleura, evidently following pneumonia.

HIPPOCRATES, (*Kuhn, Disease II, vol. 2, pp. 285*).—"Another Disease.—When the duration of the disease becomes longer, the fever is severe and the cough is increasing, and the side is painful, and he cannot bear to lie upon the well side, but has to lie on the side of the disease, then the feet swell, and the hollows of the eyes. When the fifteenth day after the rupture arrives give him a profuse bath of hot water, sit him in a firm seat that he may not move, let an assistant hold his hands, while you shake his shoulder and listen to hear on which side the pus makes a splash. Hope it is on the left so that you can make your incision on that side, for it is less deadly. If on account of the thickness of the tissues and the fulness of the cavity it does not give out a sound, so that you cannot make out where it is, which sometimes occurs, make an incision on the side which is more swollen and painful, rather below and behind the swollen part, so that an easy outlet may be afforded for the pus. First incise the skin between the ribs with a broad knife, then wind the blade of the knife with a strip of linen leaving out the point to the breadth of a thumb nail, and push it in. Then when you have let out as much pus as you think best, stuff the wound with a drain of raw flax to which a thread is attached. Let out the pus once a day. On the tenth day when you have let out all the pus dress it with fine linen. Then introduce through a small tube a mixture of oil and wine, warm, so that the lung which has gotten used to the moisture of the pus may not be suddenly dried. Draw out the liquid which has been injected at night in the morning, and that injected in the morning at night. When the pus becomes thin like water, and feels slippery to the finger and is small in quantity put in a hollow tin tent. When the cavity is entirely dry, cut off the drains a little at a time and allow the incision to heal, till you take out the drain. An indication that the patient will recover: if the pus is white, clear, and has fibers of blood (like blood clot?) they generally get well. If on the first day the discharge is the color of egg yolk, and in the next thin and greenish with a bad odor, they die when the pus has run out."

OPERATION FOR EMPYEMA (*Littre, ON DISEASES, vol. 7, pp. 150*).—After a long course of expectorants, etc., he goes on: "If treated in this way these diseases get well unless a little of the sputum is left behind in the lung, and becomes purulent. Under these circumstances the cough becomes dry, and fever, chills, and orthopnea set in; the breathing is rapid and the voice a little harsher and the face is red on account of the temperature. As time goes on, the disease becomes more evident. If you get hold of the case within ten days, use a heating diet and warm baths, and inject into the lung something to cause the pus to be expelled, and employ all other means to produce this result, and let the régime be suited to empyema, and keep the head dry so that no additional fluid may run down from it. And if as a result of the infusions the pus is not softened and brought up, but ruptures from the lung into the thorax, after the rupture he seems to be well, because the pus has escaped from a small cavity into a large one and the inspired air gets into its proper place in the lung. But as time goes on the chest cavity is filled with pus, and the cough and fever and other painful symptoms afflict him more severely, and the disease becomes manifest. In that case one should wait 15 days after the rupture, so that the pus may mature again; because when

the pus escapes into the large space (in the chest) it becomes cooled and mixed with fluid already in the chest, so as to be only half purulent. If he begins to cough it up of his own accord during this time, assist nature by drugs and fluids, and during the last days after the rupture encourage him to get up before his muscles get too weak, and keep his head clear to prevent catarrh. If he does not cough it up, and the signs (of empyema) become evident in the chest, stop his food and drink, bathe him with warm water, place him on a firm seat, let an assistant take hold of his shoulders, and you yourself shake him, holding your ear to the chest, so as to see on which side the signs appear. Hope it is on the left, because it is more deadly to cauterize, or incise on the right. As much as the right side is the stronger, by so much the diseases on that side are more violent. If the fluid is too thick to splash so that there is no sound in the chest, while the breathing is rapid, the feet swollen, there is a short cough, do not be deceived, you may be sure that the chest is full of pus. Dip a thin piece of linen cloth in Eretrian clay, moistened and finely powdered, and wind it around the chest, and the place where it dries first is the place to cut or cauterize, as near as possible to the diaphragm, but be on your guard not to injure it. If you prefer you may anoint the chest with the Eretrian earth, and observe just as you did when you used the linen, being careful to anoint the whole chest at the same time, lest the part anointed first, dry too soon. After you cut or cauterize, use a drain of raw flax, and let the pus out gradually. When you are going to cut or cauterize, see that the patient keeps the same position that he is to be in when you operate, in order that you may not be deceived by the skin slipping upward or downward. In your treatment look out for coughing, that the pus may not be sucked back into the chest, but drained off dry as soon as possible. On the tenth day, let out all the remaining pus, stuff the opening with linen, and let out the pus twice a day, and keep the chest as dry as you can by régime. This is the way to examine and treat empyemata resulting either from injuries, pneumonia or severe catarrh, or falling of the lung against the pleura."

ON DISEASES (*Littré, Book II, vol. 7, pp. 93*).—ABSCCESS IN THE CHEST.—"When an abscess forms in the chest there is a dry cough, pain, and fever. There is a sensation of weight in the pleura, and a sharp pain always in the same place, severe thirst, warm drinks are regurgitated and the patient cannot lie on the painful side, but is able to lie on the unaffected side, but when he lies down he feels as if a stone were hung from him. The side swells and reddens, and the feet also swell. This requires incision or cautery, then let the pus run out till the tenth day and plug with raw flax. When the tenth day comes, inject warm wine and oil, so that the cavity may not at once become dry, and stuff with linen. Let out the injected fluid, and reinject. Do this four days running. When the fluid becomes as thin as strained barley broth, and small in amount, and sticky to the touch, put in a tin tube, and when the cavity is quite dry cut off a little of the tube and continue until the cavity contracts gradually down on it."

SERUM IN THE LUNG.—"If fluid gathers in the pleura, fever and cough take place, and rapid respiration, and swelling of the feet, and the nails all become curved, and the symptoms are those of empyema, but milder and more chronic. And if you perform infusion or give a vapor bath or fumigate, pus does not come up. In this way you can recognize that not pus, but serum, is present. And if you listen a long time with the ear against the chest, it boils inside like vinegar. This goes on for some time and then it ruptures into the (pleural) cavity. Then at first the patient seems well and free of his disease. Then in time the cavity fills up, and the same symptoms occur in

more aggravated form. In some cases the abdomen, the scrotum and the face become edematous, and some conclude the trouble comes from the lower abdomen, when they look at the swollen abdomen and edematous feet. For these swell also, if you fail to incise at the right moment. If such a patient shows external swelling he must be treated by an incision into the pleura. If external swelling is not present give a thorough hot bath, seat him as you do in empyema and on the side you hear the splashing sound incise. Try to make the incision as low as possible for better drainage. When you have incised, dress the incision with raw flax, making the drain thick and pointed at the end, and let as little of the fluid as possible escape at one time. Then if pus appears in the dressing on the fifth or sixth day, most of them get well, if it does not appear when you have drawn off all the serum, thirst and cough seize on the patient and he dies.

AUSCULTATION IN THE HIPPOCRATIC WRITINGS.—In paragraph 59 of the second book on "Diseases" the writer is describing a disease called "The Falling of the Lung Against the Chest Wall." He is undoubtedly speaking of the false membranes which develop in a dry pleurisy, and the friction rub which develops as a result. The writer describes the cough, painful and difficult respiration, states that a noise like leather is heard, and he adds, he seems to breathe through the chest. After describing the treatment he goes on to say, "If this results from a wound or from the incision of an empyema (for it sometimes does), tie a bladder to a tube, fill it with air and inject it into the chest, and put in a hard tin plug and push the lung back. You will have the best luck with this sort of treatment." Here is the ancient germ of nitrogen injections in phthisis, to push the lung away from the chest wall, and put it at rest.

We know that Laennec, the discoverer of auscultation, recognized that some of these facts about auscultation were hidden away in the Hippocratic writings from which neither he nor anyone else had unearthed them. He cites the passage in paragraph 61, on dropsy, on "Serum in the Lung." "And if you listen a long time with your ear against the chest, it boils inside like vinegar." I suppose these we should call "fine moist râles." Anyway he held his ear against the chest, and could hear more or less what was going on inside. That is the way he heard the friction rub "like leather," and that is how he heard the splashing sound in empyema. That is all we possess about auscultation in the Hippocratic writings, but that is sufficient to show that they were familiar with direct auscultation and recognized certain characteristic sounds. All these attempts, which were manifested intelligent interest, slept in their books without being developed, or even understood, till Laennec, who by controlling the sense of hearing by pathologic anatomy, pushed auscultation so far and rendered such service to the art of auscultation.

HYDROPS (*Littré, vol. 7, p. 224, Par. 23*).—"Hydrops results from causes like these. When one gets thirsty in the summer season, and drinks a great deal of water very fast, this disease is most likely to occur. For the lung being saturated discharges it into the chest. In the chest it causes severe fever so as to melt the fat, which surrounds the bronchi, and when the fat begins

to melt in large amounts, in a little while the serum collects. It occurs also when swellings appear in the lung, are filled with serum, and burst into the chest. That hydrops results from swellings in the lung, witness the occurrence of swellings both in the cow and the dog and the pig. In these quadrupeds most frequently occur swellings in the lung containing serum. If you incise them you will quickly recognize this fact, for the serum will flow out. It seems that such swellings occur in man much oftener than in cattle, for as much as we employ a more unhealthy diet. Many cases also of empyema have resulted from such swellings. The following symptoms occur at the outset of the disease: dry cough, hoarseness of the throat, chills, fever, and orthopnea, the skin is dropsical, the feet swell and the nails become curved. While the fluid is in the chest, the distress is severe, when it gets down into the lower abdomen, the patient seems easier. Then as the disease progresses and the abdomen gets filled up, the former symptoms return. Sometimes a swelling occurs on the chest, and shows us where to cut. If the point is not evident give a copious hot water bath, take hold of his shoulders and shake him, then listen to hear on which side there is more splashing. Having ascertained this cut down over the third rib from the last down to the bone. Then bore through it with an augur, and when you have cut through, let out a little of the serum, and having let it out plug it with raw flax and place a soft sponge over it; then bandage so that the plug will not fall out. The fluid ought to be let out once a day for 12 days. After the twelfth or thirteenth day let off all the fluid, and after that if any fluid collects, let it out, and administer foods which will dry the cavity. The following remedies ought to be administered after the operation. Prepare a dram's weight of silphium, grate a piece of aristolochia as big as a fawn's knuckle, take a pint measure of clean barley meal, and the same amount of lentils or vetch, mix this with honey and vinegar, and make 60 pastilles. Then every day dissolve one of these in a half a cup of dark wine, the more astringent the better, and let him take it on a fasting stomach. Order him to pursue the same regimen and exercise as previously, and if his legs and thighs swell, incise them confidently. If you treat the patient in this way, you will quickly restore him to health."

A brief extract from Hippocrates on "Wounds" or "Ulcers," shows that the Greeks had the same word for both, and that they had an idea of first intention, and aimed to get it when they thought it possible, but as our author remarked, "Judgment was difficult." Also we note they too moisten no wounds with anything but wine, which was the nearest thing to alcohol they had.

HIPPOCRATES, ON WOUNDS (*Kuhn, vol. 3, p. 307*).—"No wounds should be moistened with anything except wine unless the wound is in a joint. Because dryness is more nearly a condition of health, and moisture more nearly allied to disease. A wound in moist and healthy tissue is dry. It is better to leave a wound unbandaged, unless a cataplasm is applied. Certain wounds ought not to have cataplasms applied. Fresh wounds are less suitable for cataplasms than old ones, and wounds in the joints. Restriction in the amount of food, and drinking nothing but water are most useful in all wounds, more especially in the recent than those which are old, or for some reason inflamed, or likely to become so; or when danger of necrosis exists, or inflamed wounds about the joints, or where there is danger of convulsions; also in wounds of the abdomen, but most of all in fractures of the skull and femur or any other

bone. Standing erect does wounds the most harm, especially if the leg is the wounded part. Patients ought neither to walk about, or even be allowed the sitting position. Rest and quiet do the most good. Recent wounds, as well as the surrounding parts, will be less liable to inflammation, if one can induce suppuration as soon as possible, and not let the pus be blocked up in the opening of the wound, or if one can bring it about that it does not suppurate at all, except the little pus that necessarily appears, but keep it dry with some remedy that is not too harsh. For if it is dried to excess fever will come on, as indicated by chills and throbbing. For the wounds become inflamed when they are going to suppurate on account of the alteration and heating of the blood, till it softens and pus appears, in wounds of this sort at least. When you decide that a cataplasm is indicated, do not apply it to the wound, but to the surrounding parts, so that the pus may have free exit, and the tissues which are hardened rendered soft. In wounds made by the cut or thrust of a sharp weapon a remedy which will stop hemorrhage is indicated, as well as something which will prevent suppuration and dry up the wound. When the flesh has been lacerated and contused by the weapon, the wound should be treated in such a way as to produce suppuration as quickly as possible. Because (if this is done) it will be less inflamed, and the tissues which have been contused and lacerated and putrid and purulent have to soften and come away. After that new tissue sprouts up. It is a good plan in fresh wounds, except those in the abdomen, to allow a lot of blood to escape, as much as you think is required for the purpose, both from the wound itself, and any lacerations of the surrounding parts, especially in wounds of the leg or fingers or toes. On account of the escape of blood the parts are drier, and less swollen. These conditions prevent the wound from becoming moist, indeed, for the most part suppuration results from the presence of blood, and the changes which take place in that blood. It helps after the escape of the blood to bandage over such wounds a piece of sponge, soft and thick, and cut to the appropriate size, preferably dry, rather than moist, or to place leaves of delicate texture over the sponge. Oil or softening or greasy remedies are not good for such wounds, unless they are already well on their way to a cure. Oil is not good for fresh wounds either, neither are greasy or fatty remedies good for them especially when the wound needs a lot of cleansing. To sum up, use oil only for anointing in both winter and summer, or for such conditions as is needed.

"It is a good thing to move the bowels by enema in most wounds, especially in head injuries, and wounds of the abdomen and joints; also when there is danger of gangrene, in sutured wounds, in wounds which corrode, and undermine the tissues, and others which are slow to heal. But when you decide to bandage, do not smear on the ointment before you have thoroughly dried out the wound, then put it on; but sponge out the wound many times with a sponge, dry it with a clean dry fine linen cloth applying it many times. Having applied in this way the remedy which you think will be useful, either bandage it or not, as seems best. For most wounds warm weather is more favorable than winter except those in the head and abdomen. The equinoctial season is still better. These wounds which have been thoroughly cleansed as far as is necessary to make the granulations dry generally do not produce exuberant granulations. If a piece of bone has sloughed out on account of cauterization or trephining or any other cause, the scar resulting from the wound becomes concave and the cleansed wounds are reluctant to heal. They come together under compulsion, but not of their own accord. These in which the wound is surrounded by inflammation do not heal until the inflammation has ceased, nor are wounds likely to heal, in case the surrounding parts are

blackened either from softened blood, or blood supplied by an adjoining varicosity and they won't heal at all until you get the surrounding parts into a healthy condition.

CIRCULAR WOUNDS.—“If there is a cavity beneath, it ought to be incised clear around with a circular incision, or half way around, to an extent corresponding to the nature of the case. In every case complicated by erysipelas, the system should be cleaned out by catharsis in the direction most suitable to the particular cases, either upwards or downwards. When edema occurs around a wound, at a time after the inflammation has subsided, the edematous tissue has pus under it. A wound which has swollen on account of inflammation, and does not subside when the other parts which become inflamed at the same time have themselves subsided, is in danger of not healing readily. In cases resulting from falls or some other injury by which the tissues surrounding the wound are torn apart or crushed and swollen, and suppurate, the pus from the swollen part runs out of the wound. In these cases, if you think cataplasms are needed, do not apply the cataplasm to the wound. Rather apply it to the surrounding parts, so that the pus can get out, and the hardened tissues soften down. Where they have softened and the inflammation has ceased, bandage on sponges so as to bring the separated edges together, beginning with the healthy parts and gradually progressing. Bandage plenty of leaves over the sponge. When edges cannot be brought together because the tissues are moist, this tissue has to be cleared out. If the wound extends deeply under the flesh on both sides, both on account of the bandaging and the weight of the dressing it will rise up in curved surfaces in the center. If one will incise such a wound on a director, widely if it can be done, to allow free drainage, one should incise outward from the opening of the wound in the direction which seems to afford the best chance and in this way apply remedies, whatever you think are indicated. Generally speaking one ought to get a clear look straight into any wound which has a cavity in case there is no swelling. If now there is any putrefaction in it, or the flesh lining it is moist, and rotten, that wound and the surrounding tissues will be dark and greenish in appearance, and the mordant ulcers, where there is spreading gangrene, feed on the tissues and eat into them. This kind of ulcer also will be surrounded by dark greenish colored tissue.”

Page 134.—“A cataplasm for swelling and inflammation in the surrounding parts. Boiled mullein, raw trefoil leaves, with boiled sedum leaves and polium. If the wound needs to be cleared out these are all cleansing, also fig and olive leaves and leeks. These must all be boiled, and especially agnus (castus), fig, olive and pomegranate leaves. The following should be used raw. Mallow leaves crushed in wine, also leaves of red and green origanum. One should mix with all these flax seed roasted and powdered as finely as possible. When erysipelas threatens following a wound, crush the raw leaves of woad and apply with the flax seed, or moisten the flax seed with the juice of nightshade or woad, and apply it. When the wound itself is clean, but inflamed, together with the surrounding tissues, boil lentils in wine and reduced to a fine powder, use a little oil with it and spread it on and bandage. Also boil the leaves of the dog briar in water, powder it finely and spread it on. Spread a clean piece of thin white linen over it, and wet it with a mixture of wine and oil. When you want to bring the wound together prepare the leaves of the dog briar just as you did the lentils or nasturtiums and mix fine flax seed with it. This is the way to use flax seed and green agnus castus, and ‘apple alum,’ moisten them with vinegar.”

Page 326.—“Swellings of the feet of spontaneous or non-spontaneous origin which do not subside under cataplasms (either the swelling or the in-

flammation), or respond to bandaging or sponges or wool or something of the sort to the healthy part, but following this swell up of themselves and become inflamed, the reason for this is the congestion of blood in the veins, unless it is accounted for by a contusion. If a similar condition exists in any other part of the body, the cause is the same. Here the blood must be evacuated preferably by the veins over the part, if they are in evidence. If not, puncture the swellings deeply and at numerous points. In this case and any other where punctures are made, do it in this way, and employ the sharpest and thinnest knives, and when you take away the blood with the probe, do not bear down so hard as to produce contusions. Wash with vinegar and do not leave any clotted blood in the openings of the veins. Anoint carded, unwashed wool with a hemostatic remedy and bind it on loosely, drench with oil and wine, and put the bandaged part in such a position that the blood will flow upward (toward the body) and not downward. Put the patient on a light diet and let him drink nothing but water. If on removing the bandage you find the punctures inflamed, apply the cataplasm made from agnus castus and flax seed. If the punctures ulcerate and connect with one another, use the remedies suitable to finish the cure.

"When there is a varix in the leg either projecting or concealed beneath the skin, and the leg is bluish black and appears to need blood letting, by no means puncture the legs, because in most cases large ulcers result from the punctures, on account of the congestion of the veins. One should in these cases open the varix in several places, where it seems to be needed. When you open a vein, if when you loosen the fillet and let the blood out, it does not stop bleeding, hold the part so that the blood will flow in the opposite direction, whether in the leg or the arm, as if to force the blood backward, and have the patient lie in that position for a longer or shorter time. Then bandage in the same position, leaving no clot in the cuts. Then put on a double pad, after moistening it with wine, and above this clean wool soaked in oil. Even if the flow of blood is excessive this will stop it. If inflammation comes on because a blood clot forms in the incision, it will suppurate. The incisions should be made after partaking freely or moderately of breakfast with its accompanying liquid nourishment, and when the patient is warm, preferably on a warm day than a cold one.

"In applying a cupping glass, if blood continues to flow after you take away the glass, especially if much blood or ichor flows from the cuts put it on again quickly before it is filled, and suck out what is left. Otherwise clots will be left in the cuts and afterwards inflamed ulcers will result from them. Such cuts ought to be washed with vinegar and not moistened afterwards, nor should the patient lie on the cuts. Some hemostatic remedy ought to be rubbed into the cuts. When a cupping is required below the knee or over it, it should be applied with the patient standing, if he is able to stand."

The School of Coe treated hemorrhoids just as we do, by cautery, and ligature. Varicose veins were ligated and excised through multiple incisions. In the following brief description of the operation for hemorrhoids by two different writers in the Hippocratic collection, you will notice that the first writer who advocates the ligature advises the surgeon to leave one behind, presumably as we do, to avoid stricture, while the second states emphatically that all should be burned off. The advice of the second writer to let the patient cry out, because that helps to evert the rectum, is a grim reminder of what

both patient and surgeon had to endure for more than 2,000 years, until the advent of anesthesia.

HIPPOCRATES REGIMEN IN ACUTE DISEASES (*Kuhn, vol. 2, p. 99*).—LIGATURE.—“You may pierce hemorrhoids in the same way. Introduce with a needle a very coarse thread of unwashed wool, and tie off as much as possible; this treatment is safer. When it is thus compressed, treat it with remedies to cause necrosis and do not irrigate them till they have come away, and always leave one behind, *etc.*”

ON HEMORRHOIDS (*Kuhn, vol. 3, p. 340*).—CAUTERY.—“The mouths of the veins pour out blood for this reason. If bile or phlegm gets settled in the veins in the rectum, it heats these veins. The heated veins attract blood from the small veins nearest to them, the inside of the rectum is congested and swells, and the ends of the veins project, at the same time they are bruised by the feces passing out and ruptured by the collected blood, and spurt out blood, usually during dejections, sometimes without dejection taking place. Their treatment is as follows:

“First, one ought to know the peculiarities of their situation. For if you cut, excise, sew and ligate, or cause to putrefy tissues in the rectum, though these procedures seem terribly severe, you will not do any harm. I order seven or eight irons to be gotten ready, one span long and the thickness of a thick probe, curved at the end, width at the end as wide as a small obol. Purge the patient with a cathartic the day before; on the day you are to cauterize, put the man on his back with a pillow under his buttocks, and force the rectum outside as far as you can with your fingers. Get your irons white hot and burn till you dry them up and leave none untreated. Cauterize so as to leave none of the hemorrhoids uncauterized, but burn them all off. You will recognize the hemorrhoids without difficulty. They project into the interior of the rectum like bluish clusters of grapes, and spurt blood as soon as the rectum is turned inside out. Let the patient’s hands and head be held while the cautery is at work, so that he cannot move, but let him shout, for that forces the rectum outwards. After the cauterization, boil lentils and vetch crushed in water till soft, and apply for five or six days. On the seventh cut a soft sponge into a thin strip. Let the sponge be six inches wide, then put over the sponge a piece of linen of equal size, thin and smooth, smeared with honey. Then put the index finger of your left hand under the middle of the sponge, and force this as far into the rectum as possible. Then put some wool under the sponge so that it will stay where it is in the rectum. Put a bandage around the waist and attach a strip to it behind, and bring it forward between the legs and bind it to the girdle at the navel. Bandage on also that medicine which I said hardens and thickens the skin. That ought to be bandaged on for no less than 20 days. Give him for nourishment once a day broth of wheat, flax, millet, or bran and let him drink water. When he sits down to stool, irrigate with warm water. Let him take a bath on the third day.

ANOTHER TREATMENT.—“Evert the rectum, and flush it thoroughly with warm water. Then cut off the tops of the hemorrhoids. Get ready this remedy before you cut. Urinate into a copper vessel, and sprinkle finely powdered copperas over the urine, then mix it by shaking the vessel and dry it in the sun. When it is dry, scrape the residue together, powder it finely, apply it with the finger, put a piece of oiled linen over it and bandage on a sponge above this.”

ANOTHER KIND OF HEMORRHOIDS.—“A second kind of tumor like a mulberry with projecting tissue grows on the veins, and if the condyloma, so

called, projects outside and is extensive, a kind of encircling lid covers the rectum. Let the man kneel and bend over two round stones and inspect, and you will find the parts between the buttocks close to the rectum swollen. Blood will flow from within, and if the tissue is soft under this lid the condyloma may be removed with the finger. It is no harder to do this than in skinning an animal to push the finger between the skin and the muscle. One should converse while doing this, and so do it without his knowledge. When you remove the condyloma, blood will certainly flow most profusely from the raw surface. Quickly wash the parts with astringent wine in which oak galls have been macerated and the bleeding vein will disappear with the condyloma, and the lid will go back to its former place, and cure will be easy.

"If the condylomata are higher up, look at it with a speculum and do not be deceived by the latter. Because when you open it, it smooths out the condyloma, when you close it, it shows it up as it is. Scrape it off with the finger, anointed with black hellebore and on the third day irrigate with astringent wine. Do not be surprised if blood does not flow when you remove the condyloma. If you make a cut in the joints or the arms or legs, blood will not flow. If you incise above or below the joints, you will find distended veins which will bleed, and it is difficult to stop the hemorrhage in good shape. The same is true in the rectum. If you cut above or below the place where the condyloma has been removed, blood will flow. If you just remove the condyloma at its point of attachment, it will not flow. If it turns out that way all is well, if not cauterize, and guard against the irons touching the tissues, but bringing them close so as to dry them, and then apply the copperas dissolved in urine."

ANOTHER WAY TO CURE HEMORRHOIDS.—"One should have a cautery made like a small reed used in making a fence, and fit the iron into it closely. Then put a cylindrical tube in the rectum, pass in the white hot cautery, take it out often, so that the heat may be endurable and no ulcer result from burning, and the cure may take place by drying the veins. But if you do not care either to cut or burn flood the rectum with warm water, evert it, triturate some smooth myrrh and gall to a fine powder, also Aegyptian aluminum, one and a half times as much, and the same quantity of dry ink powder and apply them dry. The hemorrhoids will drop off as a result of this medicine. Do this till they disappear. Half burnt copper sulphate will do the same thing. If you want to use a suppository take cuttle shell and plumbago a third part, a little alum and copperas, gall, a little verdigris. Moisten these with boiled honey, make a large suppository, and apply it till they disappear.

"In women hemorrhoids are to be treated as follows. Douche the rectum with warm water, in which some sweet smelling myrrh has been boiled. Take powdered myrrh, washed litharge and gall, add white wine oil and goose fat and mix them thoroughly, and prescribe their use after the douche. Evert the rectum as far as possible before douching."

For fistula in ano the Hippocratic writers employed the ligature and the knife. The description of the method will be omitted on account of its length. Rowing and equitation are mentioned as causes. For the ligature a five ply thread of raw flax was used with a horse hair incorporated in it, so that if the linen thread rotted and broke the horse hair could be used to pull another linen thread through. After the ligature is tied the patient is told to go about his business. The ancient Greeks must have been somewhat immune to ordinary annoyances if they could do that. If the ligature was unsuccessful the

fistula was to be cut open with the knife or a director and packed. Blind fistulae, close to the rectum, are to have the probe forced into the rectum. They may be irrigated, but as the author says, "they will not get well until they are cut open."

HEMORRHAGE.—In the Hippocratic writings I have found nothing about the ligature, the use only of styptics cautery and pressure being advised. When we come to Galen he tells us when to try the wet Irish linen for ligatures, and advises if you cannot get that to use silk or catgut.

LIGATURE OF ARTERIES (*Galen, vol. 10, p. 941. Biblion N*).—"Sometimes hot blood full of exhalations is carried up to the head. Not the least useful of the remedies for this is arteriotomy. You have to shave the head and carefully locate the arteries behind the ear and in the forehead and the temples, and divide which appear to have more heat and pulsate most strongly. Of the smaller ones beneath the skin, if you cut a piece out of them, just as we are accustomed to do for varicose veins, you will do better. For instance, one of our best ophthalmologists cut out quite a piece of the artery which runs over the temporal muscles. Generally speaking, the ends which remain of the arteries which are cut often retreat into the connective tissues, and this applies especially to the small arteries which pulsate less violently. If on exposing it the artery appears large and pulsates violently, it is safer to apply a ligature first and then divide between. Let these ligatures be made of material which dissolves with difficulty. Such in Rome is that of the so called Gaietanoi, which is brought from the land of the Celts and is on sale mostly along the Via Sacra, which leads from the temple of Rome down to the agora. It is easy to get this in Rome, and it is very cheap. If you are practicing in another country, get silk ligatures, so called. The rich women in the Roman Empire use a great deal of this material, especially in the large cities, where there are many such women. If this cannot be obtained in the place where you happen to be, choose an aseptic material such as slender gut. For these soften easily and quickly come off from the vessels. We like to have them come off after (*i.e.*, not before), they have been covered by granulation tissue. The tissue that grows up around the cut ends of the vessels makes a kind of plug and closes the lumen. When this has occurred is the time when the ligatures may slough off with safety. The veins, on the other hand, if you ever happen to cut out a piece, it is not so necessary to ligate them with aseptic material, but anything else will do. In the case of the arteries, the continual motion opens up the mouths of the divided vessels. In the veins when they once close up, held together in any old way by a ligature, or puckered up by local applications, the surrounding tissue grows over it, especially when the patient who has been operated upon keeps still, yet more if this part is kept elevated, and the vessels have been emptied. That is just the way we treat varicosities. A varicosity is a dilated vein. Such veins occur oftenest in the legs and the scrotum."

I would like to take up the surgery of fractures of the skull, in which Hippocrates was most radical, advising opening the skull when contusion of the bone, or fracture was even suspected, and giving minute directions as to how to avoid injuries to the brain. Galen gave a wonderful description of fractures of the skull, and description of how to operate, enumerating many instruments, much like those we use now.

In order to continue the policy which was adopted at the beginning of this

paper, I thought I would collect all I could find actually stated about cancer in the Hippocratic writings and in those of Galen also. Although the search through Galen's 20 volumes is a good deal like hunting through the ocean for a few pearls of thought, as the resulting pearls are not very numerous, I will present them to you, though many may be found by future doing. It should be stated that the ancients regarded the accumulation of the so called "black bile" in the tissues as the cause of cancer.

CANCER

HIPPOCRATES. OPERA (*B. Kuhn, I. p. 251*).—"Herpes is the least dangerous of all ulcers which feed on tissues, but are hard to get rid of just as hidden cancers are." (*Ibid. p. 204*).—"Old men do not have swollen glands of this sort, but they do have hidden cancers, and cancers of the extremities, and keep them till they die." APHORISM (1011). (*Kuhn, vol. 3, p. 754*).—"Those who have hidden cancers are better not treated. If treated they die off quickly; if not treated they live a long time."

HIPPOCRATES. DISEASES OF WOMEN (*p. 794*).—"In cases where the uterus falls upon the ischium, if not quickly moved away, and returned to their proper places, they become adherent (dried on) to the ischium. Necessarily, the cervix is elevated and held high up. As a result of this position the lips of the cervix are forced to close together. From being elevated and closed, it becomes hard, and because it is closed and crippled, so that the menstrual flow is shut off, it forces the fluid up into the breast, and chest, and the lower abdomen is swollen, and the inexperienced conclude that they are pregnant. They have the same symptoms, as women who are seven or eight months pregnant, and the abdomen enlarged so as to correspond to the time, the breasts swell and milk appears to be in them. When this amount of time has passed, the breasts shrink and become smaller, the abdomen does the same, and the milk disappears, and at the time when they thought the baby would arrive the abdominal swelling subsides. When this happens the uterus shrinks to a marked extent and you can hardly find the cervix, but everything is so shrunk and dried up."

Ibid.—(*Kuhn, vol. 2, p. 795*).—"And hard tumors appear in the breast, some large and some smaller, these do not suppurate, but continually grow harder and harder. From these grow hidden cancers. When cancers are about to come on, the mouth grows bitter, and every thing they eat tastes bitter, and if you give them more to eat, they refuse it, and shut their mouths. They become delirious, their eyes are hard and they do not see clearly, and pains dart from the breasts to the neck and beneath the shoulder blades, thirst seizes upon them, the nipples are dry, and the whole body becomes emaciated, the nostrils are dry and stopped up, and are not elevated with respiration. The breathing is superficial and they lose the sense of smell. Also they do not have pain in the ears, but sometimes convulsions. When they have gone as far as this, they do not recover, but die of this disease."

HIPPOCRATES, EPIDEMICS I.—(*Kuhn, vol. 3, p. 582*).—"A woman in Abdera had a carcinoma of the breast and bloody fluid ran from the nipple. When the discharge stopped she died. *Epidem. VII, p. 702*.—A woman of Abdera had a cancer of the breast. It was one of the following sort. Bloody fluid was discharged from the breast, and when it stopped, she died." *Epidem. VII, p. 699 (at bottom)*.—"A man who had a carcinoma in his pharynx and was cauterized by us got well."

GALEN. METHOD XVI.—OPERATION FOR CANCER (*Kuhn, vol. 10, p. 929*).—

"If you attempt to cure cancer by surgery, begin by cleaning out the melancholic tumor by cathartics. Make accurate incisions surrounding the whole tumor so as not to leave a single root. Let the blood flow and do not check it at once, but make pressure on the surrounding veins, so as to squeeze out the thick blood. Then treat as in other wounds." (*Kuhn, vol. 15, p. 331*).—"We have cured cancer in the early stages, but after it has reached a large size no one has cured it without operation." (*Kuhn, vol. 10, p. 141*).—"We have often seen in the breast a tumor exactly resembling the animal called the crab. Just as the crab has legs on both sides of his body, so in this disease the veins extending out from the unnatural growth, take the shape of a crab's legs. We have often cured this disease in its early stages, but after it is grown to a noticeable size no one has cured it without surgery. In all surgery we attempt to excise a pathologic tumor in a circle, in the region where it borders on the healthy tissue. On account of the size of the vessels, especially when they happen to be arteries, there is immediate danger of hemorrhage, but if you use ligatures, extension of the disease to the surrounding parts takes place. If we elect to cauterize the roots of the tumor, there is also no small danger connected with this when the cauterization takes place close to important organs. But in its beginning as I have said, we have often cured this disease, especially when the melancholic tumor is not excessively thick. This readily yields to cleansing remedies, with which it is treated."

CANCER OF THE INTESTINES: GALEN COMMENTARY ON HIPPOCRATES 25TH AP.—(*Kuhn, vol. 17, p. 688*).—"Dysentery resulting from black bile is fatal. Dysentery always is caused by that bile which is by some called 'green' and by some 'yellow'. Since the intestines are at first irritated by the bitterness of the humors, and then eroded, so as to ulcerate and produce dysentery. Dysentery resulting from 'black bile' is absolutely incurable, differing in no respect from cancer with ulceration. When we consider that such a cancer when it occurs on the surface is either hard to cure or entirely incurable, although all sorts of remedies may be brought in contact with it, it is certainly reasonable that when it occurs in the intestine and no longer cannot have a single drug brought in contact with it, but is irritated by the excretions which touch its surface, it should remain absolutely incurable."

CANCER OF THE UTERUS.—HIPPOCRATES, DISEASES OF WOMEN. (*Littré vol. 8, 337; p. 159*).—"In a woman when the uterus becomes hard, and projects through the vulva, when the groins become hard, and there is heat in the vulva, all this is likely to degenerate into cancer. Under these circumstances one should mash the interior portion of a wild cucumber and a piece of honeycomb, pour a cup of water over it and inject it into the rectum. This will produce a movement."

AMPUTATIONS: ALL GALEN SAYS ABOUT AMPUTATIONS IS TO BE GATHERED FROM HIPPOCRATES IN "JOINTS". XIII TO LXIX.—The best description of how amputations were done in ancient times occurs in Celsus de Gangrena. "If gangrene occurs anywhere between the finger or toe nail and the armpits or groins, and if medical treatment is unsuccessful, amputation ought to be done, I have elsewhere stated. I have also stated that this is accompanied by great danger. For often during the operation patients die of hemorrhage or shock. But this does not affect us, or at least there is a safe enough protection against it, and then is only once such. It consists of cutting with the knife at the line between the healthy and diseased tissue, clear to the bone, provided that the incision is not just at the joint, and one removes a little of the healthy tissue rather than leave any that is diseased. When

the bone is arrived at, the healthy tissue is to be pushed back from it, and a cut made around the bone, at the point where the bare part begins; then the bone is divided by a saw at the point as close as possible to the flesh still adherent to it. Then the edge of the bone, where the saw has roughened it, should be smoothed off, and the skin pulled over it, which should be loose in order that it may cover the bone as completely as possible. Where the skin cannot be drawn over it, it should be covered with linen and over that should be bandaged a sponge wrung out of vinegar. The after treatment should be carried out in the way prescribed for wounds, in which suppuration ought not to be induced."

ABSCESS OF THE KIDNEY

INCISION OF THE KIDNEY.—HIPPOCRATES, INTERNAL AFFECTIONS. (*Littré, vol. 7, p. 203*).—"There are four diseases arising from the kidneys. The following are the symptoms of the *First* of them. A sharp pain attacks the kidney and extends to the lumbar region and the hip and the testicles on the same side; urination is frequent and every little while there is suppression, and sand is passed with the urine, and when the sand comes out through the urethra, there is severe pain in that organ. When the urine is all passed the pain stops; after that the same pains recur, and when he urinates he rubs his penis on account of the pain. Many physicians who do not understand the disease, when they see the sand conclude that the patient has a stone in the bladder, but that is not the case, the gravel is in the kidney. This disease results from mucus, when mucus collects in the kidney, which cannot expel it, it hardens in places, forming small stones like gravel. When things are in this state, give the entire body a vapor bath, and then produce a moderate evacuation with the juice and seeds of scammony. On the following day evacuate with two cups of the juice of white chick pea, salt it at the time he drinks it. After that treat him by suitable foods and drinks, and baths and employ the remedies which are suited for strangury. When the pain is oppressive bathe copiously with hot water and apply hot applications to the part where the pain is most severe. When swelling occurs and becomes prominent, at that time make an incision into the kidney, let out the pus and treat the sand by diuretics. If the incision is made he has a chance to recover, if not, the disease will end in death."

SECOND DISEASE OF THE KIDNEYS.—"Violent pains oppress the patient as in the disease previously described. The disease results from hard labor, because the vessels in the kidneys become ruptured, so that the kidneys fill with blood. When this disease occurs the patient passes blood with the urine at the beginning, and later as time goes on, pus. If the patient will keep absolutely quiet he very quickly recovers. If he labors, the pains will take hold much harder. When the kidney contains pus, a swelling appears in the back. This patient under these circumstances you must incise deeply over the swelling, clear down into the kidney. If you hit it you will cure him right away. If you fail there is danger that the incision will prematurely close. If the wound grows together the cavity of the kidney will fill with pus; if it breaks into the bowel and passes by the rectum, there is hope of escape. But if it extends to the other kidney the patient is likely to die. Treat the patient with just the same remedies as in the previous disease, and employ the same regimen. The disease is a serious one, and may, as a result of it, go on to consumption of the kidneys.

"In the *Third* disease the urine appears like the juice of roast beef, and results from the pressure of black bile in the urine. The pains are similar to

those in the previous disease. Treated without operation, the disease never gets well. In addition to the remedies already stressed the drinking of whey and milk is recommended 'in season', for 25 days. If you carry out this treatment you may cause some benefit.

"The *Fourth* disease occurs in summer from the entrance of bile and phlegm into the urine. It also occurs as a result of excessive sexual intercourse. The pains involve the same parts as in the preceding, and resemble those of childbirth, and do not let up when he lies on the healthy side, but grow more severe, and seem to be suspended from the flank as if about to break away. If he lies on his face the pain stops. The feet and legs are cold, and the urine can hardly be passed on account of its heat and thickness. On standing, a sediment resembling barley meal is seen and if there is much bile it is reddish. If the mucus predominates it is white and thick. At first he suffers these symptoms for a year more or less. If the disease lasts a long time, the pain gets worse and suppuration takes place, and is accompanied by swelling, cut into the kidney, where the swelling is greatest and let out the pus, and if you hit it you will cure him right away." The remaining treatment is the same as in the previous diseases. "If you do these things and he does not get well at once, it will be nothing extraordinary, for this disease is obstinate."

THE PRINCIPLES OF PHYSIOLOGY INVOLVED IN THE MANAGEMENT OF INCREASED INTRACRANIAL PRESSURE

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EVERY surgeon must think about his problems physiologically but it has been difficult for me on invitation to precipitate out of the medium of my own clinical thinking principles of physiology which are appropriate for publication. Exchange of ideas is so free among neurosurgeons that I can no longer recognize my own contributions and must therefore lay little or no claim to originality for the statements which follow.

The circulation of the cerebrospinal fluid which Cushing has aptly termed the third circulation may be obstructed at any point in its course from the ventricles where the fluid is formed to the fissure of Sylvius and subarachnoid spaces where it is absorbed. Such obstruction results in ventricular dilatation due to increase of ventricular pressure from the maximum normal of 100 Mm. of water to between 400 and 700 Mm. From a practical point of view it is my opinion that there is no such thing as a hypersecretive hydrocephalus, nor have I ever been able to recognize a hydrocephalus due to obliteration of the vein of Galen.

The result of blockage of the cerebrospinal fluid pathway is a ventricular dilatation which follows a certain pattern. The dilatation begins far proximal to the site of the block and works downward toward it. Thus blockage of the interpeduncular cistern at the base of the brain (Fig. 1, A) causes dilatation of the lateral and third ventricles initially and later on the aqueduct of Sylvius, the fourth ventricle, cisterna magna and finally the pontine cisternae more or less in that sequence.*

When the dura is left open over an obstructed ventricle that ventricle enlarges with no decrease in the intraventricular pressure and the intervening portion of brain is destroyed with surprising rapidity. This destruction occurs whether the decompression be placed under the temporal or occipital muscle or elsewhere.

Thus after a negative exploration has been carried out in the presence of ventricular dilatation it is wiser to close the dura tightly unless it can rea-

*It should be pointed out that an occasional exceptional case is encountered in which the cerebrospinal fluid spaces are closed and the ventricles progressively enlarge without the measured intraventricular pressure rising above 150 to 200 Mm. of water. Such cases lead one to wonder what may be the effect upon the cerebral hemispheres of adequate closure of the subarachnoid space. Is the supposed circulation of fluid between perivascular space and subarachnoid space essential to normal metabolism of the cerebral tissue? Is it not possible that closure of that space may have a directly destructive effect upon the hemispheres?

sonably be hoped that the decompression may give to an underlying tumor enough added "elbow room" to free the cerebrospinal channels at the point of compression or unless it is desired to thin out the brain in a certain area so as to prepare the field for a second stage tumor removal.

In the case of a suboccipital craniotomy, if the tumor is found to extend so far forward that the surgeon cannot remove it completely the blockage of the basal cisternae is not relieved. Under such circumstances the result of leaving the dura open over the cerebellum would be the rapid destruction

Fig. 1



FIG. 1.—Sagittal section of skull. (A) Interpeduncular cistern. (B) Cisterna magna. Dotted line—Outlet for supratentorial structures. Broken line—Outlet of posterior fossa.

of the cerebellum with little or no relief of the hydrocephalus. True decompression and relief of the block could then be secured only by splitting the tentorium from its free margin outward (Fig. 2, broken line). This maneuver which has been recommended by Naffziger may well relieve both the aqueduct of Sylvius and basal cisternae so that the fluid may once again circulate freely.

Ventricular drainage into the tissues anywhere in the body results in absorption of fluid for a short time only. There forms rapidly an endothelium-like covering which seems to be an effective barrier to further fluid absorption. Such short lived absorption takes place into the scalp after many operations as evidenced by frequent postoperative pitting edema of the scalp and swelling about the eyes. Repeated puncture of the ventricles relieves the pressure temporarily but is followed in many instances by a higher rise

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in the pressure as though the fluid formation had been increased by the temporary drop in the pressure of the fluid that bathes the choroid plexus.

The effect of expanding lesions above the tentorium demonstrates the fact that the brain is not a fluid structure and pressure is not conducted intracerebrally according to the laws which obtain in a closed fluid-filled space. An expanding lesion in one hemisphere produces a generalized increase of intracranial pressure, it is true, but the falx and tentorium offer enough resistance so that taken with the brain's elasticity the intrahemispherical pres-

Fig 2

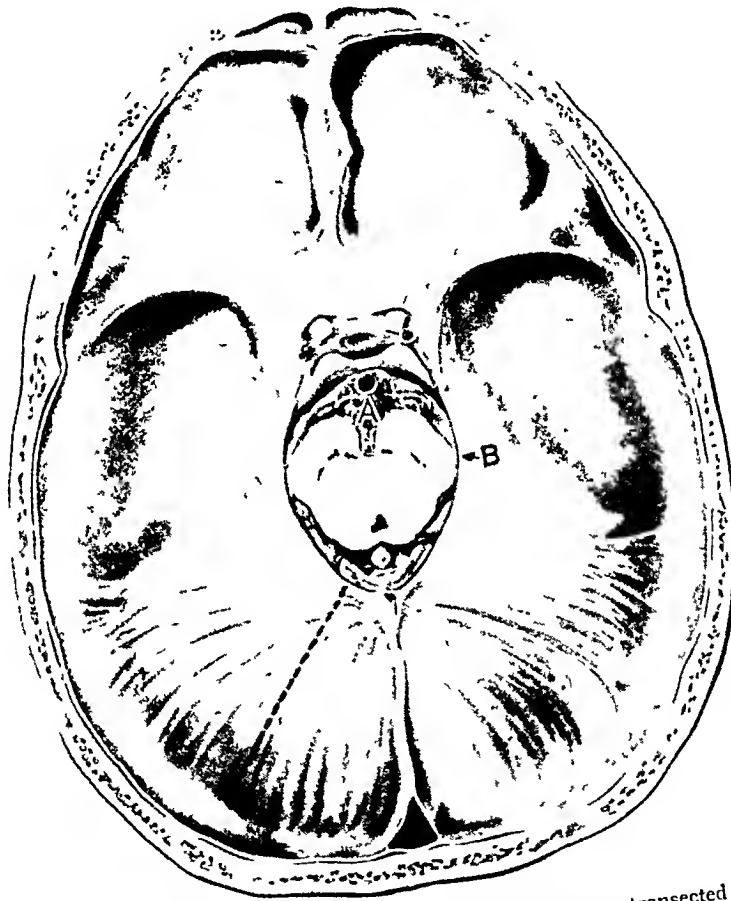


FIG. 2.—Base of skull with tentorium intact and brain stem transected at level of the incisura of the tentorium. (A) Interpeduncular cistern.

sure on the same side is greater than on the other side. Consequently when bilateral trepanation is performed in such a case cerebral tissue herniates through a small dural opening under greater pressure on the ipsilateral than it does on the contralateral side.

An expanding lesion in or upon one hemisphere usually produces a decrease in the size of the ventricle of the same side and an increase in the size of the ventricle of the opposite side. This increase very often amounts to dilatation. The mechanism of this contralateral hydrocephalus varies with the position of the expanding focus but for the most part pressure is exerted indirectly against the midbrain which cannot be displaced because it is ringed

about by the falciform edge or incisura (Fig. 2). Thus, caught between the expanding hemisphere and incisura, the aqueduct of Sylvius is closed sufficiently so that fluid can escape through it only when the ventricular pressure becomes very high. This back pressure must act equally upon ipsilateral and contralateral ventricle, but the higher pressure within the ipsilateral hemisphere counteracts the tendency to dilatation on that side while the lower intracerebral pressure permits dilatation on the opposite side.

Such indirect pressure upon the midbrain may produce another effect of practical clinical importance. It causes the cerebral peduncle of the opposite side to be cut by the sharp edge of the incisura of the tentorium. This may result in a pyramidal defect on the ipsilateral side of the body including grave paresis.

For example, a patient whom I saw recently was found to have a right homonymous hemianopsia and paralysis of the left arm and leg. In the presence of increased intracranial pressure this indicated an expanding lesion of the left occipital lobe and a lesion of the pyramidal tract from the right hemisphere. Ventriculography showed the expanding lesion to be in the left occipital lobe as surmised and the right lateral ventricle to be dilated. An intracerebral blood clot was evacuated from this lobe and the patient rapidly recovered from the left hemiplegia. Thus the expansion within the left occipital lobe had affected the left motor cortex not at all but had compressed the midbrain against the opposite edge of the tentorium at B in Fig. 2, thus closing the aqueduct and injuring the opposite peduncle against this sharp edge.

In any case, of course, the cause of expansion should be removed radically but when this is impossible or ill-advised subtemporal decompression may be of the greatest help. The decompression should be on the side of the lesion and it may thus result not only in giving more "elbow room" for the brain but it may free the aqueduct of Sylvius from its compression between expanding lesion and tentorium and thus abolish the contralateral hydrocephalic pressure which can so seriously complicate the situation. Decompression on the opposite side would be of no help whatever and as we have pointed out above would only result in destruction of the portion of brain exposed.

Small lesions near one foramen of Monroe may, of course, produce a unilateral hydrocephalus on the same side of the cranial cavity. If an expanding lesion does not produce ventricular dilatation on either side then it may be temporarily relieved by subtemporal decompression on either or both sides.

As the result of an expanding lesion anywhere in the cranial cavity two pressure cones may be produced. First the temporal lobes may be crowded into the incisura of the tentorium (A, Fig. 1, and B, Fig. 2, dotted line), even to the extent of producing a bilateral pyramidal tract compression and probably also loss of consciousness. Secondly a pressure cone may be formed at the foramen magnum (Fig. 1, B), the outlet of the posterior fossa. A portion of the cerebellum is crowded down into this foramen producing

evidence of bulbar compression, Cheyne-Stokes breathing, and respiratory failure.

An expanding lesion in the posterior fossa presents certain characteristic difficulties. It causes local pressure and closes the aqueduct of Sylvius, thus producing hydrocephalus above the incisura of the tentorium. This results in a secondary pressure downward through the exit of the middle fossa (Fig. 1, A) against the already embarrassed structures in the posterior fossa which include the medulla oblongata. Such a lesion also tends to close the pathway for fluid through the basal cisternae as seen in Figs. 2 and 3. This in turn must further increase the pressure due to fluid formation by the choroid plexus within the fourth ventricle.

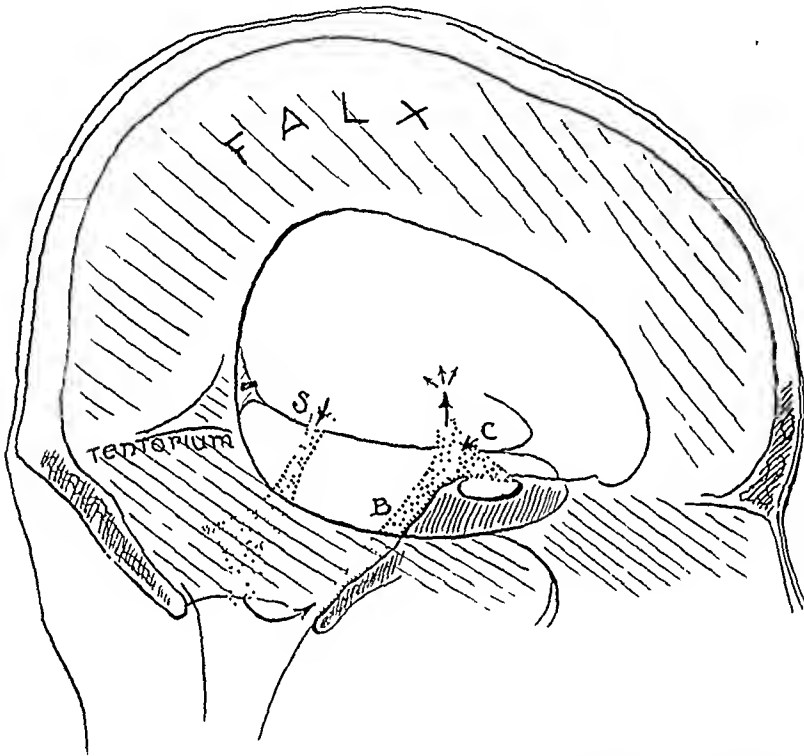


FIG. 3.—Schematic drawing of skull with dural reflections in place to show the relation of aqueduct of Sylvius (S), and basal cisternal passage (B) to the incisura of the tentorium. (C) Interpeduncular cistern.

This is, of course, the explanation of many of the sudden deaths that occur in such patients when they are straining, as at stool. This explains why a patient with a tumor of the posterior fossa who complains of transient attacks of dizziness or blackness before the eyes should be looked upon as a candidate for emergency operation.

Lumbar puncture should usually be avoided but if carried out should be done with a small needle and the pressure as shown by manometer never reduced by more than one-half its initial value. Encephalography by the lumbar route should usually be avoided but if carried out the pressure should be kept high, oxygen used instead of air and the spinal pressure at the close left at least as high as it was found initially.

If the ventricles are tapped oxygen should be used for ventriculography.

Instead of producing the dangerous secondary rise of pressure that follows air, oxygen seems to cause a fall of pressure, apparently being absorbed from the ventricles progressively, as pointed out to me by my associate, Doctor Cone. Here again, however, much less disturbance is produced if the gas is injected under a pressure equal to that of the preexisting ventricular fluid and not under a lower pressure. But, in spite of all this and however such injections are done, radical operation if indicated at all is best carried out the same day, for the least disturbance may upset the pressure balance and cause respiratory failure.

When bulbar ischemia has resulted in Cheyne-Stokes breathing or in arrest of respiration, oxygen by nasal catheter or tracheal tube is obviously indicated, and five or ten per cent of CO₂ might be added without damage, as indicated by Carl Schmidt's recent work. After the bulb has been deprived of oxygen too long suboccipital decompression and opening of the foramen magnum and arch of atlas are of no avail. No tissue in the body is more certainly destroyed by ischemia of a few minutes' duration than the brain, as shown by Cobb and others, and the neurosurgeon who decompresses the medulla oblongata under artificial respiration only a few minutes too late is forced to watch his patient die a few hours later.

Diffuse cerebral edema is a baffling complication which follows cerebral trauma whether due to head injury or to operation. The question of its mechanism would lead us into a pathological discussion not called for in this address.

Following the work of Weed and Wegefath, hypertonic solutions were used intravenously by clinicians as well as magnesium sulphate by mouth or by rectum in order to lessen such swelling. It has been shown that this shrinking effect is transitory, disappearing often within the hour as measured by a needle left in the spinal canal, and some observers believe a greater pressure follows after the temporary relief. Consequently these procedures have recently become somewhat less frequently used. Lumbar puncture takes off the added weight of the pressure of ventricular fluid, the absorption of which is temporarily blocked by the superficial edema. Repeated lumbar punctures do not remove enough blood to be of any importance from that point of view for Sprong showed that however full of blood the spinal fluid may be, and even though the lumbar puncture needle be wielded by the most persistent of picadors not more than from two to five cc. of whole blood are actually thus removed in a whole series of punctures.

After operation, drainage of spinal fluid through a stab wound in the scalp is sufficiently safe for some days and will relieve the secondary complication of fluid pressure during the period of initial cerebral edema. At the time of closure a surgeon must decide whether he will leave the bone flap floating and thus allow strain to be exerted upon the scalp incision by cerebrospinal fluid, or whether he will wire the flap back into place. In making the former choice he is forced at times to defend the suture line by

aspiration beneath the flap or by drainage. In case the bone flap and dura are closed he is more often driven to lumbar puncture. In any case, whatever the technic, the intracranial pressure is lowered by any means that can be employed to drop the venous pressure of the large veins of the neck and the head should therefore be higher than the thorax and there must be no constriction of the neck after operation and when venous hemorrhage is feared most.

In conclusion, intelligent surgical therapy demands an understanding of the principles of physiology involved in cases of increased intracranial pressure. These principles include the mechanisms of hydrocephalic dilatation of the ventricles, the rôles of the falx, tentorium and foramen magnum under such circumstances and the uses and dangers of decompression.

DISCUSSION.—DR. WILLIAM J. MIXTER (Boston, Mass.).—It seems to me in the past we have done decompression without knowledge of what we were doing physiologically.

It has been a great pleasure to hear Doctor Penfield. He has given us reasons pro and con concerning decompression and I feel sure that the acceptance of these principles will be of great value.

I would like to ask Doctor Penfield why it is that a certain number of patients in the past who presumably had brain tumors which were never proven were markedly relieved for a considerable period of time by subtemporal decompressions.

DR. WILDER PENFIELD (Montreal, Canada).—I find it difficult to answer the question. I think there are a certain number of cases of pseudotumor which are in reality, of course, not tumor at all, but actually cases of collection of subdural fluid either secondary to trauma or secondary to some primary inflammatory process in one of the sinuses.

I think in those cases there is a collection of a fluid, high in protein, within the subdural space, which cannot escape. Consequently decompression allows the fluid to drain into the muscles and it does not reform, so that in some cases there have been permanent cures from decompression or trepanation.

THE DIAGNOSTIC VALUE OF PHOSPHATASE DETERMINATIONS IN THE STUDY OF BONE TUMORS

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ROBISON¹ suggested in 1923, that the enzyme phosphatase played an important rôle in the formation of bone in the human body, and his theory is at present the most widely accepted explanation of the deposition of calcium salts in zones of ossification. A large amount of experimental evidence has strengthened this theory and has indicated that the osteoblast is the source of the enzyme.

Phosphatase is present in tissues wherever active ossification is taking place. It is also present in the intestinal mucosa and kidney in considerable amounts, but in these regions it is probably associated with the absorption and excretion of phosphorus. A small amount is found in the normal bones of adults, but it is present in the greatest concentration in the metaphyses of the bones of infants and embryos. This is reflected in the plasma phosphatase activity, which is somewhat greater during infancy and childhood.

In 1929, Kay² first reported that disturbances in bone metabolism are sometimes accompanied by an extraordinary increase in the amount of phosphatase enzyme in the blood plasma. Additional observations were reported by Kay³ and Roberts⁴ in 1930. These investigators were especially interested in the high levels of phosphatase activity in the blood in osteitis deformans. The elevation of the blood phosphatase activity in this disease has since been confirmed by many laboratories, and is now being used in several clinics as a quantitative test of the severity and progress of the disease, and also as an index of the efficacy of the therapeutic measures.

In their reports, Kay and Roberts both recorded miscellaneous observations on the blood plasma values in other diseases of bone, including bone tumors, and found that the phosphatase activity of the blood plasma was somewhat elevated in certain cases. More recently, Bodansky and Jaffe,⁵ Austoni and Coggi,⁶ and Coryn⁷ have also reported series of phosphatase determinations in various bone disturbances. These reports indicate that it is considerably elevated in rickets and somewhat elevated in the regenerative stage of osteomyelitis. Hunsberger and Ferguson⁸ have shown it to be slightly elevated during fracture repair. It is also elevated in jaundice (Roberts⁹). Albright, Aub and Bauer¹⁰ have reported elevated blood phosphatase determinations in cases with osteitis fibrosa cystica in which the elevation is, roughly, in proportion to the degree of bone involvement.

During the past two years we have been making determinations of the phosphatase activity of the tumor tissue as well as of the blood plasma in

all cases of bone tumors made available to us. Many of these cases and the details of the methods employed in making the determinations have been reported by one of us in a previous communication (C. C. F.¹¹).

The object of this report is to stimulate in other clinics interest in the study of the phosphatase content of the blood and tissues in cases of bone tumors, in order that a sufficient number of observations may accumulate to determine the value of the test as an aid in diagnosis.

We have followed Kay's¹² technic in the determination of the phosphatase activity of the blood plasma. By this method the phosphatase activity is expressed in arbitrary units the normal limit of which is about 0.26 units per cc. A few of the determinations here reported were made on blood serum by the Bodansky¹³ method in the Chemical Laboratory of the Massachusetts General Hospital through the kindness of Dr. Fuller Albright, but the values have been translated into their approximate equivalents in Kay units to eliminate confusion. The normal upper limit for the Bodansky method is about five units per 100 cc. of serum. The technic for the determination of the phosphatase content of the tissues was modified slightly from that introduced by Martland and Robison,¹⁴ and has been previously reported in detail.¹¹

We have observations on 72 cases of bone tumors of various types. In 65 cases, we have observations on the blood plasma, in 32 cases on the tumor tissue, and in 21 on both. The diagnosis in all cases of primary bone tumors, and in many of the others, has been verified by biopsy, unless otherwise stated. These cases may be divided as follows:

TABLE I
BONE TUMORS—PHOSPHATASE ACTIVITY
Cases Studied

	Cases
(1) Osteochondroma.....	7
(2) Giant cell tumor.....	6
(3) Multiple myeloma.....	11
(4) Endothelial myeloma (Ewing).....	8
(5) Osteogenic sarcoma	
Osteoblastic type.....	13
Osteolytic type.....	3
Chondral type.....	2
(6) Adamantinoma.....	2
(7) Metastatic malignant disease.....	15
(8) Inflammatory conditions (tuberculosis, syphilis, etc.)....	4
(9) Myositis ossificans.....	1
	—
Total.....	72

We have not included any cases of generalized osteitis fibrosa cystica in this series. We have also excluded osteitis deformans from considera-

tion for the elevation of plasma phosphatase in this disease is well known.

In the following discussion the average plasma phosphatase of cases of a given group at the time they first came under observation is reported, and the differences among the groups compared.

Benign Osteogenic Tumors. Osteochondroma (Seven Cases).—The plasma phosphatase in this group was within normal limits with the exception of one case, a tumor of rapid growth, in which it was slightly elevated. The average was 0.29 unit. The tumor phosphatase was in general elevated above that of normal bone (five cases); the average was 5.3 units per Gm.

Giant Cell Tumor (Six Cases).—The plasma phosphatase in three cases was normal and in two somewhat elevated. One of the latter two patients was a child of six years, and the other an adult with a large tumor and a pathologic fracture. The diagnosis in this case was not confirmed by biopsy. The average plasma phosphatase in this group was 0.31 unit. The tissue phosphatase activity (three cases) was moderately increased, averaging 8.5 units.

Plasma Cell Myeloma (11 Cases).—Only one case showed the plasma phosphatase above normal limits (0.34); the average was 0.19 unit. In patients presenting multiple destructive lesions of the bones by radiograph an elevated phosphatase seemed to be of value in differentiating myeloma from multiple metastases in carcinoma, or from generalized osteitis fibrosa; for in the two latter conditions the phosphatase was almost invariably elevated above the normal limits. We have two observations on myelomatous tissues, and in both the activity was negligible. It is interesting to note in passing that the serum protein in the blood was elevated in the seven cases in which the determination was made.

Endothelial Myeloma (Ewing Sarcoma), (Eight Cases).—In all cases but one, a postoperative case with recurrence in the lung and the ilium, the plasma phosphatase was somewhat increased but never more than twice the normal. The average for the eight cases was 0.27 unit. The level appeared to bear no relation to the extent of the disease. There was a negligible activity in the tumor tissue in the two cases available for study.

Adamantinoma (Two Cases).—In both cases the plasma phosphatase was within normal limits; the average was 0.19 unit. The tumor phosphatase activity was elevated in one to 15.5 units.

Metastatic Malignant Disease in Bone (15 Cases).—In every case of metastatic disease in bone, the plasma phosphatase was at the upper limits of normal or elevated. Eight of these patients were cases of carcinoma of the breast, two carcinoma of the kidney, two carcinoma of the prostate with bone metastases of the osteoblastic type, one neuroblastoma, and one melanotic sarcoma. The average plasma phosphatase of the entire group was 0.60 unit. As in myeloma, there seemed to be little relation between the extent of bone involvement and the plasma phosphatase reading. It was no greater in the osteoblastic form of cancer of the prostate than in metastases from cancer of

the breast with osteolytic lesions of similar extent. The phosphatase activity of metastatic tumor tissue was low, with the exception of the case of metastatic neuroblastoma, which in gross showed considerable new bone laid down in sun-ray pattern. In this case it was 26.4 units per Gm.

Myositis Ossificans (One Case).—The plasma phosphatase was considerably elevated (0.78 unit) when the patient was first seen, one month after the injury, and the radiogram at this time showed a large area of new bone in the quadriceps femoris muscle. Six weeks later the radiogram showed bone of a more adult character and the phosphatase had dropped to 0.38 unit.

Inflammatory Conditions (Four Cases).—Plasma determinations were made on one case of bone syphilis, one case of bone tuberculosis, and two cases of periosteal irritation caused by pressure from tumors of the soft parts. In none of these cases was the reading above a high normal.

Osteogenic Sarcoma (18 Cases).—The osteogenic sarcomata appeared to fall into three main groups as far as the phosphatase activity of the cells was concerned. These may be termed the osteolytic, osteoblastic and chondral types.

Chondral Type (Two Cases).—There were two examples of this form in the series. These tumors were of relatively slow growth and of a low degree of malignancy. Both have been submitted to and accepted by the Registry of Bone Sarcoma of the American College of Surgeons as sarcoma. Plasma determinations were not made on either of these cases. The activity of the tissue in both cases was low. The average was 3.8 units.

Osteolytic Type (Three Cases).—The plasma phosphatase was determined in one case, and was elevated to 0.43 units. Two tissue determinations showed moderate activity, 10.0 units.

Osteoblastic Type (13 Cases).—In the cases in this group the plasma phosphatase was greatly increased. There seemed to be little relation between the activity in the plasma and the size of the tumor, but the plasma value bore a definite relation to the enzyme activity of the tumor tissues. The average plasma activity was 1.22 units, or five times what may be considered a high normal. Both Kay, and Bodansky and Jaffe, have reported cases of bone sarcoma in which the activity of the plasma was from two to five times normal. The tissue phosphatase activity varied within wide limits but was high in every case with one exception. In this case, one of sarcoma in Paget's disease, the activity of the tumor tissue was negligible. This was also the only case in which the plasma phosphatase reading did not return to normal after amputation. There is a possibility that the tissue examined was not representative of the tumor, as it was taken from the periphery; but in several other instances the activity of the tissue from the soft peripheral portion of the tumor was as great as that from portions containing new formed bone. The average for the group was 65.9 units per Gm. of tissue.

Repeated blood determinations were made at intervals after surgical removal of the tumor in six cases in this group. In every case the phosphatase activity fell to normal within three weeks. This is shown graphically

PHOSPHATASE IN BONE TUMORS

TABLE II

PLASMA PHOSPHATASE ACTIVITY—BONE TUMORS
(Normal Limits to 0.26 Units per cc. Kay's Method)

	Cases	Average Phosphatase Units per cc.
Osteochondroma.....	6	0.29
Giant cell tumor.....	5	0.31
Multiple myeloma.....	11	0.19
Endothelial myeloma (Ewing).....	8	0.27
Osteogenic sarcoma		
Osteolytic type.....	1	.43
Osteoblastic type.....	13	1.22
Metastatic carcinoma.....	14	.60
Adamantinoma.....	2	.19
Myositis ossificans.....	1	.78
Miscellaneous inflammatory.....	4	.20
Total.....	65	

TABLE III

TUMOR TISSUE PHOSPHATASE ACTIVITY—BONE TUMORS

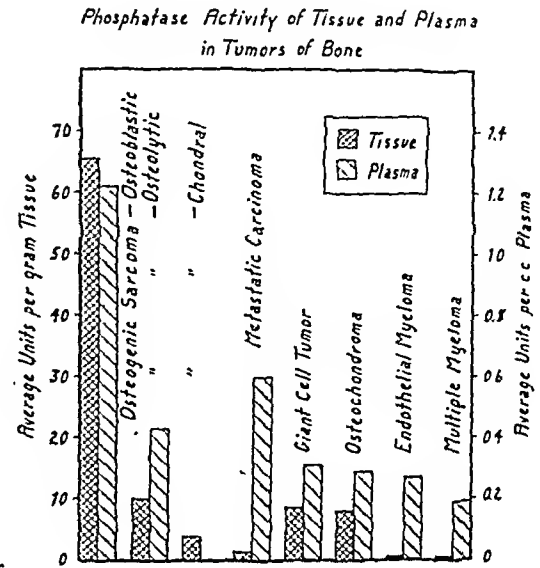
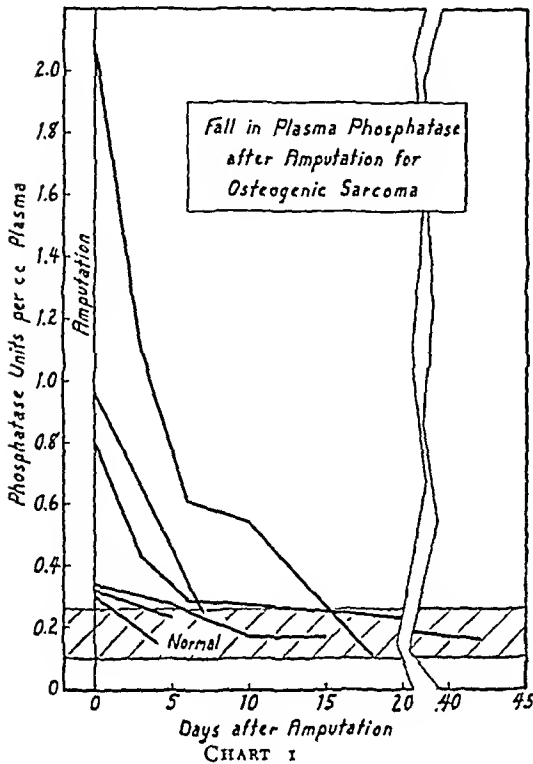
	Cases	Average Phosphatase Units per Gm.
Osteochondroma.....	5	5.3
Giant cell tumor.....	3	8.5
Multiple myeloma.....	2	Trace
Endothelial myeloma (Ewing).....	2	Trace
Osteogenic sarcoma		
Chondral type.....	2	3.8
Osteolytic type.....	2	10.0
Osteoblastic type.....	11	65.9
Metastatic carcinoma.....	4	1.3
Adamantinoma.....	1	15.5
Total.....	32	

in Chart I. One of these cases returned several months later with evidence of lung metastases, and at this time the plasma showed renewed activity. In a second case a normal plasma activity was found at the first determination, 20 months after amputation for an osteogenic sarcoma of the tibia. At this time the radiograph showed a small, indefinite shadow in the lung, and the diagnosis lay between calcified tuberculous nodes and metastatic sarcoma. Ten months later the shadow had increased and there was little doubt but that it represented metastasis. The phosphatase reading at this time was definitely elevated. We have been unable thus far to anticipate the radiologic diagnosis of lung metastases after amputation for sarcoma by examination of the blood. The reelevation of the plasma phosphatase activity with recurrence of the tumor, however, somewhat parallels the observation of Ferguson¹⁵ who demonstrated the reappearance of Prolan A in the urine with recurrence in certain cases of testicular tumors.

A fall in the plasma phosphatase was noted in two cases of osteogenic

sarcoma shortly before death. This may be interpreted as due either to necrosis of the tumor or to starvation.¹⁶

The effect of radiation of the tumor in relation to the activity was noted



in one case. There was a temporary fall after radiation, but the reading later rose to a higher level than that recorded before treatment. Wilkins and Regen¹⁷ have reported similar temporary inhibitory effects of radiation on the phosphatase activity in normal bones in young rabbits.

SUMMARY

From these observations on 72 cases it seems justifiable to draw certain tentative conclusions, although more work must be done before any authoritative statement of the value of the determination of the plasma phosphatase activity as an aid to the diagnosis of bone tumors can be made. We believe, however, that the test should be done whenever possible and that, taken in conjunction with other facts, it will be found to be of value in differentiating certain forms of bone tumor. The only tumors in which it was found consistently to be elevated were metastatic carcinoma and osteogenic sarcoma.

Our findings may be summarized as follows:

(1) The plasma phosphatase reading is normal or low in non-malignant bone tumors.

(2) It is normal or very slightly elevated in multiple myeloma and in endothelial myeloma (Ewing sarcoma).

(3) It is normal or slightly elevated in the giant cell tumor of bone.

(4) It is considerably elevated in malignant disease, metastatic in bone, and this fact may be of value in differentiating the multiple bone metastases of carcinoma from endothelial myeloma and multiple myeloma.

(5) It is consistently high in osteogenic sarcoma of the osteoblastic type. In the osteolytic type (one case) it is approximately the same as in the group of metastatic carcinoma and giant cell tumor.

(6) Following surgical removal of an osteogenic sarcoma the plasma phosphatase falls to normal in the course of from two to three weeks, but again becomes elevated when there are demonstrable metastases.

(7) The recurrent tumor must attain an appreciable size before an increased plasma phosphatase activity can be demonstrated.

(8) In individuals dying of osteogenic sarcoma the activity diminishes shortly before death.

(9) Radiation treatment of an osteogenic sarcoma caused a temporary diminution in the plasma phosphatase activity in one case.

(10) The plasma phosphatase activity bears a definite relation to that of the tumor tissue.

(11) The high phosphatase activity of the tumor tissue in osteogenic sarcoma is an example of a neoplastic cell continuing to produce the physiologic secretion of the normal cell from which it is derived.

(12) In one case of myositis ossificans the plasma reading was high at the time of osteoblastic activity in the lesion.

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DISCUSSION.—DR. CLIFFORD C. FRANSEEN (Boston, Mass.).—The enzyme phosphatase has become of increasing clinical importance in recent years. Its determination has already been used in such conditions as Paget's disease of bone, in hyperparathyroidism, and in rickets, in all of which the activity of the blood is high. In Paget's disease it appears to be a good index of the severity and the progress of the disease. A few reports of blood phosphatase determinations in bone tumors have appeared in the literature, but we have been unable to find any account of previous study of the phosphatase activity in bone tumor tissue. Since the enzyme can be found in great concentration in tissues where ossification is taking place, as in the metaphyses of embryo and infant bones, it appeared reasonable to suspect its presence in osteogenic tumor tissue. This we were first able to show over two years ago, and the present report is the result of subsequent study on both tissue and plasma.

The technic of the determination of phosphatase activity is not difficult and can be performed by any trained technician. It requires no apparatus other than that which is standard equipment in any clinical laboratory. The tissue determination requires a simple preliminary extraction in distilled water, and can be made on as little as one cubic centimeter of tissue. The phosphatase activity is measured by incubating the blood plasma or tissue extract with a buffered solution of a phosphoric ester under controlled conditions of time, temperature and pH. The number of milligrams of phosphorus split off by the enzyme is measured colorimetrically as in the ordinary phosphorus determination, and the value thus obtained is expressed in units of activity. The blood phosphatase determination has already been made a routine procedure in a number of hospitals.

The possible use of the tissue phosphatase activity as a supplement to pathologic study, in differentiating sarcomas of fibroblastic origin contiguous to bone from those of osteoblastic origin, is suggested from some of our observations. One biopsy specimen was of particular interest, since its phosphatase activity was high, although the microscopic picture resembled that of a fibrosarcoma. Since tumors of fibroblastic structure have at most a very slight phosphatase activity, the diagnosis of osteogenic sarcoma was offered and later confirmed at amputation. This seems to indicate that the osteoblast is already producing phosphatase in its undifferentiated state. Other specimens from the periphery of tumors have been examined and have shown as great an activity as central specimens containing osteoid tissue and new bone. We have not as yet had an opportunity to investigate this aspect of the problem thoroughly.

There is a growing number of examples among tumors of neoplastic cells which continue to produce the secretion of the cells from which they are derived, notably the adenomas of the endocrine glands. In all these instances, however, the secretion is a hormone. The present study suggests that we have here an example for an enzyme produced by the malignant osteoblasts.

We hold no brief for the phosphatase determination as the solution of all the difficulties encountered in the differential diagnosis of bone tumors, but in certain situations it may be of assistance. Additional observations are necessary to determine its ultimate value.

SOME PHYSIOLOGIC PRINCIPLES INVOLVED IN THE SURGICAL TREATMENT OF GASTRIC AND DUODENAL ULCER

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THE problem of the cause of gastric and duodenal ulcer is of constant interest to the physician who has to deal with these lesions and to the biologist who recognizes in it a part of the more general question of the resistance of the gastro-intestinal tract to the digestive action of its own secretions. From the time of John Hunter various men have interested themselves in this problem and the view has steadily gained headway that ulcer of the stomach is in some way due to a local loss of resistance on the part of the mucous membrane to the digestant activity of the gastric juice. The term peptic ulcer is an expression of that view. The occurrence of the lesion in those parts of the alimentary tract that are exposed to gastric juice (lower esophagus, stomach, first portion of duodenum, jejunum adjacent to a gastro-enterostomy stoma, and ileum adjacent to the entrance of a Meckel's diverticulum containing gastric mucosa) and nowhere else may be taken as strong confirmatory evidence. But under normal conditions the mucous membrane of the stomach is not digested away.

During the past 15 years there has been a renewed interest in the problem and many significant observations made. As a direct result of various experimental procedures the disease has been caused to develop in the lower animal and to duplicate in almost every particular the lesion encountered in man. The gross and histologic appearance of the experimental ulcer exactly resembles the clinical lesion, and it has been observed to perforate, to cause profuse hemorrhage, and to heal under a type of medical management which resembles that found effective in man. In addition, the alterations in the physiology of the alimentary tract under which experimental ulcers may be expected to develop and become chronic are well understood and the factors involved may be fairly accurately appraised. Indeed, there are not many diseases whose immediate pathogeneses seem at present to be better established. It is the purpose of the present paper to offer a brief analysis of a part of this newer information and to present a summary of some of the experimental work carried on with various associates in my laboratory on this problem during the past few years.

The early literature is replete with unsuccessful attempts to produce a chronic progressive lesion in the gastric or duodenal mucosa of dogs. This effort has served, however, to make evident the great capacity of the gastric mucosa of these animals to heal in the presence of the usual gastric content and after the most extensive mechanical and chemical traumas. Exalto (1911) and Mann and his associates (1923) must be credited with being

the first to develop methods which regularly lead to the production of chronic ulcers without the use of external destructive agencies.

The normal resistance of the gastric wall to the digestant action of gastric juice has been explained as due to a general vital principle (Hunter), the protective action of gastric mucus (Pavy), the neutralizing effect of the alkaline blood in the mucosa capillaries, or to the presence of anti-pepsin in the stomach mucosa (Weinland), *etc.* It has been a fairly common assumption that the mucosa lining the gastric wall has some specific resistance to such digestion not possessed by other living tissues and entirely absent after death. In 1924, together with Vaughn,¹ I made an attempt to secure experimental evidence regarding the resistance of various tissues to gastric digestion. Large openings were produced in the stomach of dogs



FIG. 1.—Implantation of the spleen in a window made in the anterior wall of the stomach, with exposure to gastric digestion for two weeks. The capsule of the spleen was removed before implantation so that the gastric content had direct access to the splenic pulp. The blood supply to the spleen was not interfered with. The spleen was not digested, although tests indicated that the gastric juice was normal. (From Dragstedt and Vaughn, *Arch. Surg.*, vol. 8, p. 791, 1924.)

and into these defects were carefully sutured segments of duodenum, ileum, colon, and such organs of the spleen, kidney, and pancreas. In the latter case the capsule of the organ was first removed so as to permit the gastric content access to the parenchyma. In no case were these tissues digested away. The exposed surfaces of the spleen and kidney were soon covered by a layer of newly formed gastric mucosa while the mucosa of the duodenal and intestinal implants remained entirely normal for periods of at least nine months (Figs. 1 and 2). In subsequent experiments^{2, 8} similar defects were produced in the first part of the duodenum and the free portion of the pancreas sutured in place so that its parenchyma would be exposed to digestant action of the duodenal content. Digestion did not occur. It is thus evident that there exists a widespread resistance to the corrosive and solvent action of the gastric and duodenal content on the part

of tissues and organs whose blood supply is not interfered with. It should be emphasized that these experiments yield data only on the resistance of tissues to the normal gastric content but not to pure gastric juice. There is a significant difference between the two with respect to both acid and enzyme content. The concentration of free HCl in the stomach contents of normal man examined one hour after the administration of an Ewald meal varies between 30 and 60 clinical units, whereas that in the pure gastric juice secreted by the isolated stomach of the dog remains practically con-

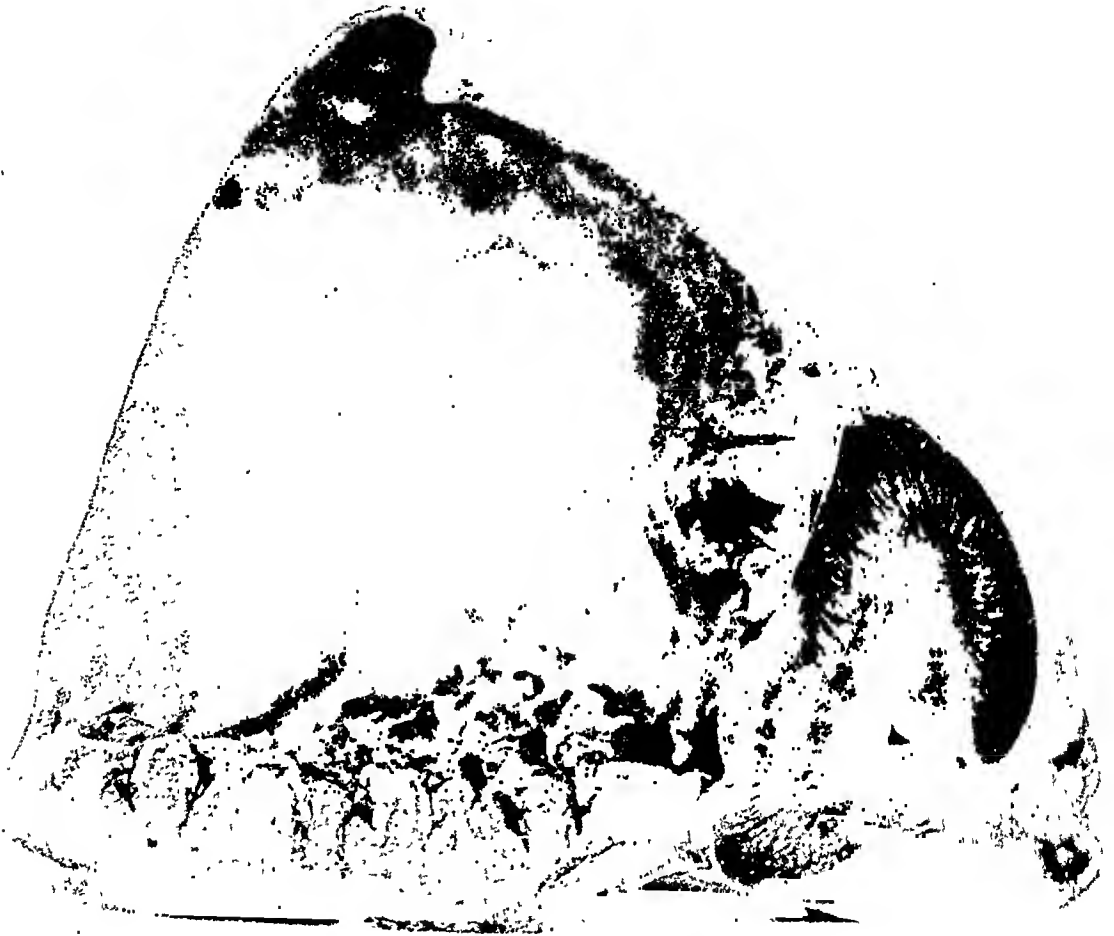


FIG. 2.—Implantation of the kidney in a window made in the anterior wall of the stomach, with exposure to gastric digestion for 14 days. The capsule of the kidney was first removed so that the parenchyma was directly exposed to the gastric content. There was no digestion of the kidney. (From Dragstedt and Vaughn, Arch. Surg., vol. 8, p. 791, 1924.)

stant at about 135 units. Carlson³ has given a similar figure for the acidity of the pure undiluted gastric juice of man. The following evidence indicates that this pure gastric juice can digest any living tissue and that an ulcer may be expected to develop in any portion of the gastro-intestinal tract that is long exposed to a content that resembles it in acid and enzyme concentration.

A.—Organs such as the spleen and kidney, which were found to remain intact if implanted into windows made in the normal stomach, are promptly digested away if implanted into similar windows made in the isolated stomach pouch where they are exposed to the digestant action of pure gas-



FIGS 3 and 4—Implantation of the spleen into a window made in an isolated pouch of the stomach. The parenchyma of the spleen exposed to the pure gastric juice of the Pyloric pouch was extensively digested.

tric juice. In two dogs, a large Pavlov accessory stomach was made employing for this purpose approximately two-thirds of the entire fundus. The pouch was connected to the exterior by means of a tight fitting metal cannula so that gastric juice could be retained or permitted to escape at will. A large window was then made in the accessory stomach and into this was carefully sutured the spleen, exactly as was done in the experiments with the normal stomach. For the first week or two the gastric juice secreted in the pouch was promptly drained away, the juice remained fairly clear

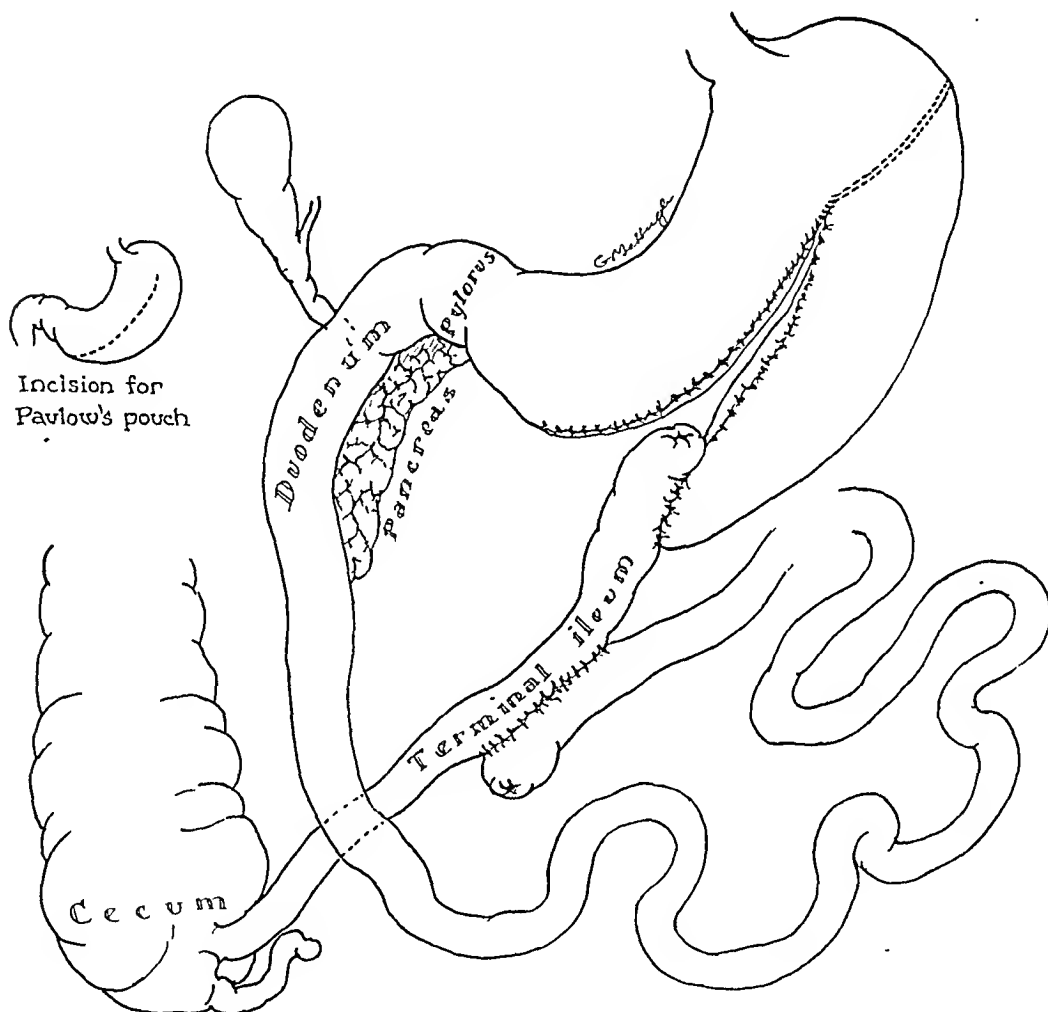


FIG. 5.—Diagram showing the method used to expose the mucosa of the ileum and jejunum to the digestant action of pure gastric juice. (From Matthews and Dragstedt, Surg., Gynec., and Obst., vol. 55, p. 265, 1932.)

and the condition of the animals excellent. The cap was then screwed over the cannula causing a retention of gastric juice in the pouch for daily periods of three to four hours. Care was taken not to permit the accumulation of sufficient secretion to distend the pouch and thus produce mechanical damage to the implant. The gastric juice draining from the pouch became immediately tinged with blood and in a few days repeated severe hemorrhages occurred. The dogs became markedly weak and cachectic. The specimens (Figs. 3 and 4) show the extensive digestion of the spleen by the pure gastric juice in striking contrast to the almost complete absence of such digestion by the normal gastric content.

B.—If pure gastric juice be caused to flow into the empty jejunum or ileum, the mucosa is digested away and an ulcer is formed. This experiment was performed in the following way (Fig. 5). A small isolated pouch of the dog stomach was made, in some cases with the vagus innervation intact (Pavlov pouch), in others with the vagi cut (Heidenhain pouch). The open end of these accessory stomach pouches was then sutured into the jejunum or ileum. Gastric juice secreted in the isolated stomach in response to meal taking passed immediately into the as yet empty intestine. In six animals in which the gastric juice was made to pass into the ileum an ulcer developed in the adjacent area in every case (100 per cent) and in the jejunum in 11 of a total of 13 experiments or 85 per cent⁴ (Fig. 6). The ulcers always developed in the intestinal wall adjacent to the line of anastomosis with the stomach, but never in the gastric mucosa. They presented



FIG. 6.—Showing a large ulcer in the jejunum near the anastomosis with the Pavlov pouch, as in Fig. 5. The unmixed gastric juice secreted by the isolated stomach has digested the jejunal mucosa. (From Matthews and Dragstedt, Surg., Gynec., and Obst., vol. 55, p. 265, 1932.)

the same clean, punched out appearance of the lesion in man. Several caused profuse hemorrhage, many perforated, and none showed any tendency toward spontaneous healing.

Nature performs an experiment similar to this in the so called Meckel's diverticulum ulcer, an example of which has recently come under my care.⁵ Aschner and Karelitz⁶ and Lindau and Wulff⁷ have collected a number of cases in the literature in which an ulcer has been found in the ileum adjacent to the entrance of a Meckel's diverticulum. In these cases the diverticulum has been found to be lined with heterotopic mucosa which in some instances has been proved to secrete acid and pepsin.

C.—If the stomach be isolated from the gastro-intestinal tract in such a way that its blood supply and vagal innervation are but little interfered with and so that the gastric juice secreted is not promptly drained away but remains in contact with the gastric wall for a time, the gastric mucosa then

becomes digested away and chronic progressive perforating ulcers develop that anatomically are not distinguishable from the clinical lesion.

In a study of the physiology of gastric secretion, Lim, Ivy, and McCarthy in 1925 isolated the entire stomach of dogs, and sutured the lower end of the esophagus to the open end of the duodenum. Although the vagus nerves to the isolated stomach were cut, from 300 to 400 cc. of highly acid

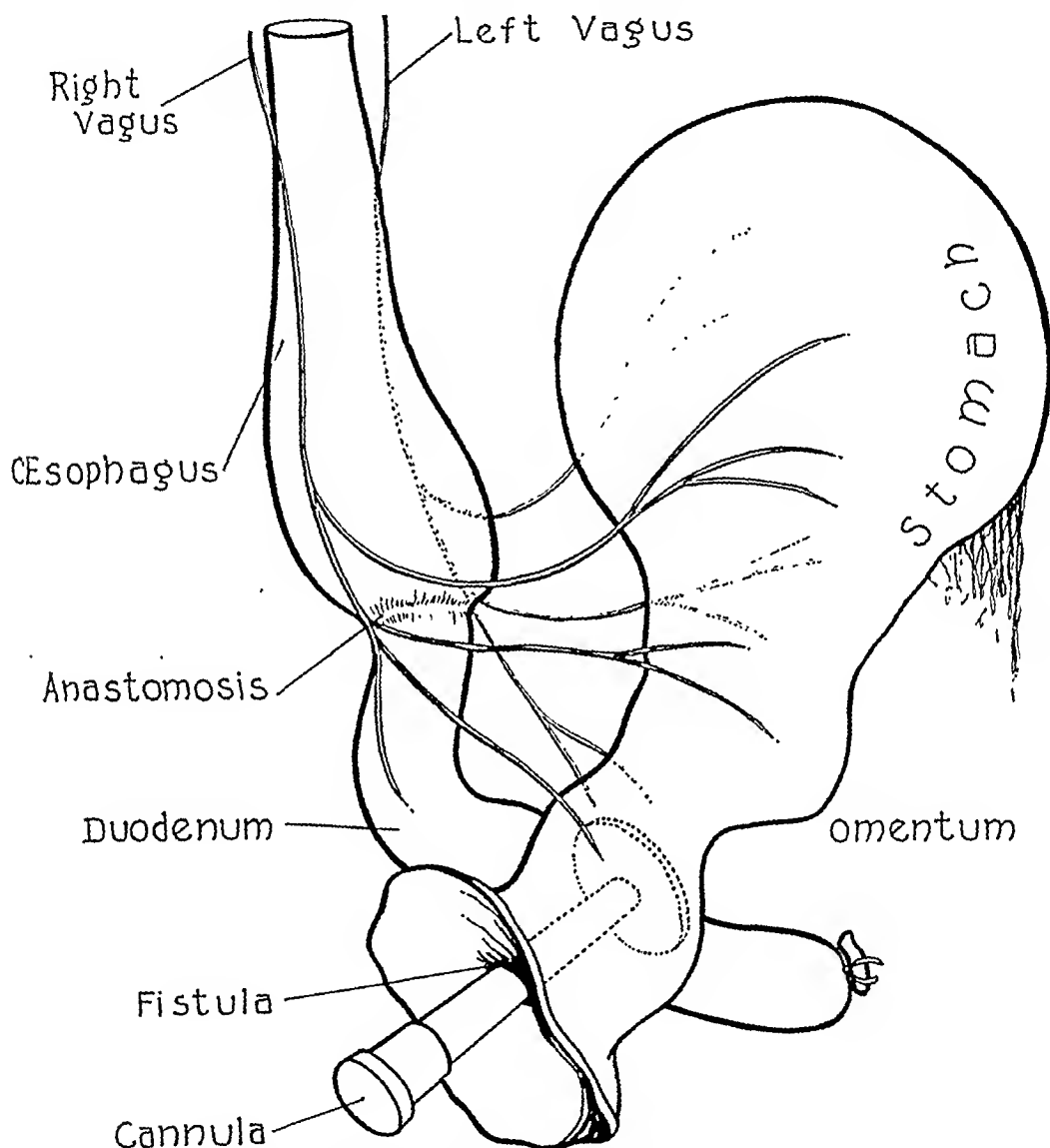


FIG. 7.—Diagram showing the method of preparation of the isolated stomach with vagus innervation intact. (From Dragstedt and Ellis: *Am. Jour. Physiol.*, vol. 93, p. 407, 1930.)

proteolytic gastric juice were secreted daily. It occurred to us that a more physiologic preparation would be one in which the vagus innervation of the stomach was preserved, if possible, since the Pavlov pouch in which this is the case more nearly mirrors the activity of the normal stomach than does the Heidenhain pouch where the nerves have been severed. In a number of instances, we were successful in so isolating the entire stomach that its blood supply and vagus innervation were left intact (Fig. 7). To our surprise, such an isolated stomach was found to secrete on an average about 2,000 cc. of gastric juice per 24 hours. The free hydrochloric acid of this secretion varied between 100 and 140 clinical units and its pepsin concentration

was approximately three times as great as that of the normal gastric content. The continued loss of this secretion produced dehydration, hypo-

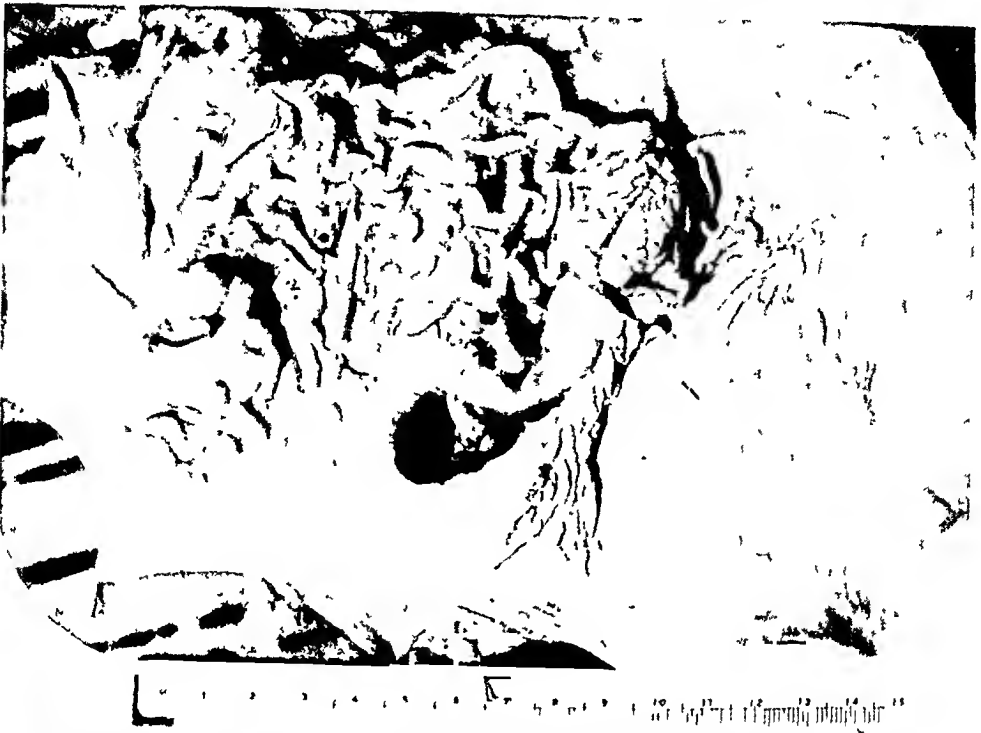


FIG. 8.—Large ulcer in the wall of the isolated stomach, as in Fig. 7. Death from perforation and peritonitis 20 days after original operation.



FIG. 9.—Large ulcer in the wall of the isolated stomach, as in Fig. 7. Death from perforation and peritonitis 43 days after original operation.

chloremia, alkalosis, and eventually death unless sodium chloride was supplied in large amounts by intravenous injection. During the course of these experiments we came to the realization that if this pure gastric juice was

permitted to accumulate in the isolated stomach or if its drainage to the outside was not adequate, ulcers would develop in the gastric mucosa. To date typical chronic ulcers have been noted in seven animals (Figs. 8 and 9). In several instances these caused death from hemorrhage and in two cases from perforation. In one experiment, in which death occurred from pneumonia 48 hours after the operation, several superficial ulcers were found and the entire mucous membrane presented numerous small erosions, areas of round cell and leukocytic infiltration, and hemorrhages quite similar to those described by Konjetzny¹⁴ as characteristic of ulcer gastritis (Figs. 10 and 11).

If we may conclude from these experimental observations that pure



FIG. 10—Large superficial ulcer and multiple erosions on the wall of an isolated stomach as in Fig. 7. Death from pneumonia 48 hours after operation.

gastric juice can digest away living tissues including the mucosa of the digestive tube, the question may be raised as to the substance in gastric juice responsible for this effect. Our inquiry in this respect has been limited to pepsin and free hydrochloric acid. If one can judge at all by the widespread use of the term peptic ulcer it would appear that many regard pepsin as the responsible corroding agent. In this connection it is perhaps pertinent to point out that trypsin is an even more active proteolytic enzyme but no ulcers have been reported in that part of the digestive tract exposed to pancreatic juice. The question is not entirely an academic one. The late Doctor Sippy based his method of treatment on the idea that pepsin was the principal agent that prevented the healing of ulcer and so endeavored to prevent the activation of the pepsinogen by preventing the appearance of free acid in the gastric content at any time. Very large amounts of alkalis were sometimes necessary to secure such complete neutralization.

Claude Bernard showed many years ago that the leg of a living frog

would be digested away if introduced through a fistula into the cavity of a dog's stomach. We have confirmed this observation in *in vitro* experiments¹ and have modified the method in an attempt to assay the relative importance of acid and of pepsin. The hind legs of living frogs were immersed in pure gastric juice, in pure pancreatic juice, and in gastric juice containing varying concentrations of free hydrochloric acid and pepsin. The legs immersed in pure gastric juice were gradually digested away so that in a few hours all that remained was a branching network of blood vessels surrounding the bones. Although usually the last to persist, the vessels were finally eroded and death from hemorrhage occurred. It is interesting that pure activated pancreatic juice had no such digestant effect and the skin remained intact though edematous even after 25 hours' exposure. Pure gastric juice of



FIG. 11.—Low power photomicrograph of one of the superficial erosions in the gastric mucosa of the isolated stomach of Fig. 10.

normal pepsin concentration but whose free acidity was reduced to 30 clinical units or less had no digestant or corrosive action, whereas juice having a concentration of free acid of 50 units or more had a very marked effect almost irrespective of the concentration of pepsin. When the concentration of free acid and of pepsin was varied in different samples, the extent of digestion of the living tissue was proportionate to the concentration of free acid and not at all to the concentration of pepsin. Somewhere between 0.1 and 0.15 per cent of free hydrochloric acid was found to be the critical level at or above which living tissue was digested. At this concentration it made little difference whether the concentration of pepsin was 600 or 20 units per cc. It is doubtless significant that the acidity of the normal gastric content rarely rises above this level and that the high values which approach the acidity of pure juice are commonly found in ulcer patients.

It must be admitted that the experimental conditions under which the

ulcers described above have been caused to develop are highly artificial and with few exceptions their counterpart does not occur in man. If it be agreed that the evidence warrants the conclusion that a gastric content whose acidity and pepsin concentration approaches that of pure gastric juice will digest the wall of the stomach or duodenum and produce an ulcer and is in this sense its immediate cause, there still remains the question—under what conditions, if any, does such a content appear? This latter problem is obviously of greater practical significance and here unfortunately our information is far less precise. It seems clear enough from a consideration of the normal mechanisms that govern the secretion of gastric juice, that a pure undiluted and unneutralized secretion is not apt to accumulate in the stomach. The sight, odor, and especially the taste of food which serve as appropriate stimuli for the nervous phase of gastric secretion are followed so promptly by the ingestion of food that the juice is diluted and neutralized. Similarly the gastric secretion which results from the action of gastrin takes place only while food is in the stomach and upper intestine. Under normal conditions of motility the gastric content is passed on into the duodenum before its capacity to bind or neutralize the free hydrochloric acid is entirely overcome, so that we never observe in the digesting stomach a free acidity equal to that of pure juice and rarely an acidity above that at which gastric juice was found capable of digesting living tissue. When an abnormal retention of food in the stomach occurs, we should expect on theoretical grounds that the continuing secretion of gastric juice would gradually raise the acidity of the gastric content until it approaches the acidity of the pure secretion. There is, of course, plenty of clinical data to substantiate this view and the hyperacidity of the gastric content in cases of duodenal ulcer with pyloric obstruction has long been regarded as a significant factor in determining the chronicity of these lesions. It is not improbable that pyloric stenosis or spasm may operate also in another way to raise the acidity of the gastric content. It was found by Mann⁹ and confirmed by ourselves and others that the experimental deviation of the alkaline pancreatic juice from the duodenum into the lower intestine or to the exterior is shortly followed by the appearance of chronic progressive ulcers in the duodenum. A few clinical cases have been described in which it appears that a failure of bile or pancreatic juice or both to reach the duodenum and neutralize the gastric content had been responsible for the occurrence of the duodenal ulcer. The practical significance of Mann's discovery, entirely apart from its theoretical importance, may, however, be much wider. According to the views of Boldyreff¹⁰ a reflux of bile and pancreatic juice into the stomach normally occurs and serves to prevent the development of a high concentration of acid in the gastric content. Spasm of the pylorus and especially when associated with a stenosing duodenal ulcer might be expected to limit such regurgitation as well as cause retention and thus set up a vicious circle whereby the increasing acidity of the gastric content increases the pylorospasm. It seems reasonable to conclude that the major factor in determining the chronicity of ulcer

in the pyloric region is the resulting stenosis or spasm which acts thus in two ways to increase the acidity of the gastric content. The treatment of such a lesion, therefore, which does not return the emptying time of the stomach to normal may be expected to be followed by recurrence.

It is not easy to evaluate the rôle of the central nervous system and the undoubted effect of the stress and strain of modern life (Rivers¹¹), in the pathogenesis of ulcer. Ulcers can be caused to form in portions of the gastro-intestinal tract entirely severed from any central nervous system connections so that I believe the immediate cause of the lesions is local. On the other hand, the vagi contain secretory fibers to the stomach and it is theoretically possible that these might be stimulated by other than the normal mechanism and there results a secretion of gastric juice in the empty stomach which if marked or persistent might cause ulcer. In 1927, Silberman¹² secured the secretion of gastric juice in the empty stomach by reflexly stimulating these secretory nerves. He performed double esophagostomy in dogs and gave these animals sham feedings for 40 to 60 minutes three times each day. Gastric or duodenal ulcers or erosions appeared in 18 of these dogs after periods of 16 to 49 days, and the acidity of the gastric content varied between 68 and 103 clinical units. It is possible that the acute ulcers and erosions observed by Dr. Harvey Cushing¹³ in patients following operations for cerebellar tumor have an etiology similar to those in Silberman's experiments. It is not improbable that the operative trauma to the interbrain might stimulate the gastric secretory centers associated with the vagus center and cause a large secretion of gastric juice in the empty stomach, such as was secured by the sham feeding experiments. An examination of the gastric content after such cerebral traumas would be of great interest.

A continuous secretion of gastric juice into the empty stomach during the entire 24 hours occurs both in man and lower animals. The cause of this secretion (nervous or hormonal), its amount, and its variations under physiologic and pathologic conditions are but little understood. Normally the amount seems to be small and it is readily neutralized by the gastric mucus, swallowed saliva, and regurgitated bile and pancreatic juice. There is considerable evidence that in ulcer patients the volume of this continuous secretion is greatly augmented. Does this represent hyperactivity or hyper-tonicity of the vagus secretory mechanism as a result of continued mental strain? If so, vagus secretion may find a definite place in ulcer therapy. On the other hand, acute emotional stress definitely inhibits gastric motility and prolongs its emptying time and it is entirely possible that in this way may be significant in the clinical problem.

Considerable variation exists in the resistance of various parts of the alimentary canal and other tissues to the digestant action of pure gastric juice. When the secretion from an isolated Pavlov pouch was drained into the jejunum and ileum, several weeks were required before ulcers developed, whereas the exposed spleen was extensively digested in a few days. The ileum was found to be definitely more susceptible than the jejunum and in

every instance the gastric mucosa proved to be most resistant. This lessened resistance of the small intestine to the digestant action of gastric juice must always constitute an objection to all forms of surgical therapy in which an artificial opening is made between the stomach and jejunum. In those cases where the increased acidity of the gastric content is due to retention and where the operation corrects this defect the danger of jejunal ulcer should be minimal. The advisability of a large stoma to facilitate the emptying of the stomach seems indicated. The superior resistance of the duodenal mucosa as determined by experiment suggests that gastroduodenostomy or pyloroplasty, where conditions permit their employment, are preferable to gastrojejunostomy. On the other hand, when pyloric stenosis does not exist or where the increased acidity of the gastric content is due to excessive continuous secretion of gastric juice, the probability of recurrence or secondary jejunal ulcer is very real.

The development of typical ulcers in the wall of the isolated stomach proves that pure gastric juice can digest the gastric mucosa and makes it unnecessary to postulate a specific loss of resistance to account for ulcers in the stomach proper. The careful histologic examination of a large number of resected specimens in Konjetzny's¹⁴ material failed to reveal evidence of local vascular injury, embolism, or thrombosis. It is not to be supposed that the resistance to digestion of the mucosa would always be uniform throughout or that a uniform exposure of the entire surface would always occur. Such variations should be of chief significance in determining the site of the resulting ulcer and its shape. The more general effect is manifested by the small erosions, hemorrhages, and cellular infiltrations in the neighboring more resistant or less exposed mucosa. According to this view the so called ulcer gastritis is of similar origin to the ulcer itself, is more amenable to medical treatment, and cannot be considered an indication for partial gastrectomy.

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DISCUSSION.—DR. EDWARD S. JUDD (Rochester, Minn.).—We are all greatly indebted to Doctor Dragstedt for this work. As you all know, he has investigated the pathogenesis of peptic ulcer for a great many years and has done a very good job. I hope we can make our surgical work conform to the principles that he has laid down and I think he has come closer to helping us out than any other research worker. The results which he has obtained from these experiments are strictly in accord with those obtained by Mann, Williamson and Bollman in the Mayo Clinic. It seems to me that we all feel that their experiments give sufficient evidence to show that a gastric content of sufficient acidity and concentration of pepsin can digest the normal mucous membrane of the stomach and duodenum and produce an ulcer. I think that it is, as Doctor Dragstedt says, unnecessary to postulate some local thrombosis, infection, or embolism, as has been suggested by some former investigators. When resistance is locally decreased, the digestive ability of the gastric juice undoubtedly will be more effective in producing and maintaining ulcer. I also fully agree with what Doctor Dragstedt says about gastritis as described by Konjetzny; namely, that it is attributable to the chemical action of the gastric content and that the condition is corrected when the acidity is controlled. I fully concur in his conclusion that, for this reason, the finding of extensive gastritis is not an indication for partial gastrectomy.

Mann and Bollman have stated, in an article on experimentally produced peptic ulcers, that two types of ulcerative lesions of the gastric and duodenal mucosa are produced experimentally: "The ulcerative type most often produced has always remained acute; it is usually multiple and is more often distributed throughout the mucosa of the fundus than in the mucosa of the pylorus or duodenum. The exact site of occurrence of the lesions is never definite or constant. They start as a hemorrhage in the submucosa, and the lesion of the mucosa appears secondary to the vascular injury. This type of lesion is readily produced experimentally by various means. It occurs in the so called toxic conditions, after the injection of toxins, certain drugs and bacteria, and in some moribund conditions that follow the loss of the adrenal and parathyroid glands, as well as after section of the splanchnic nerves and other operative procedures. In our experience, this type of ulcer is always acute. If the animal survives the procedure, which was accompanied by the development of the ulcer, healing always occurs, and no trace of the lesion remains.

"The other type of ulcer is the one that we have observed more commonly. The conditions under which it develops are definite and limited. The ulcer is usually single, although two or, rarely, three (hardly more) ulcers may be present at one time. The site of the lesion is in the pathway of the outflow of gastric contents; it is never in the fundus. The exact site of its development is definite and constant. It starts on the surface of the mucosa as a grayish, circumscribed membrane. At first it is saucer-shaped, and later the usual appearance of peptic ulcer as seen in man develops. In the beginning the lesion is acute, but if perforation with peritonitis or fatal hemorrhage does not occur, it quickly becomes chronic. Grossly and microscopically, this type of lesion resembles peptic ulcer as found in man.

"Whether either of these two types of lesions corresponds to the type seen in man has not been determined, owing to the fact that the process of development of the lesion in man has not been determined. If the mucosal lesion in man which precedes the development of the characteristic chronic peptic ulcer begins as a hemorrhage into the submucosa, it would appear that many of the

results of our investigations would have little, if any, clinical bearing. On the other hand, if the lesion in man begins at the surface of the mucosa, the type of lesion we have studied would appear to be the only type of experimentally produced ulcer that may be of clinical significance."

I believe that the acute type of ulcer which Mann and Bollman described is similar to the acute ulcerative lesions which Silberman produced in dogs after performing double esophagostomy and feeding a secretion of gastric juice obtained from the empty stomach by stimulating the secretory nerve. I believe that these acute ulcers and erosions described by Mann and by Silberman are the ulcers which Cushing found occurred following operations for cerebellar tumor. I do not think that this type of ulcer need be considered as simulating the chronic gastric or duodenal ulcer which is observed clinically.

The medical treatment of ulcer should be based entirely on these physiologic principles. Sometimes a great deal may be accomplished by employing a medical and dietary regimen similar to that originated by Doctor Sippy. If the patient responds satisfactorily, this plan of treatment may be continued. However, if the patient does not improve within a reasonable period of time, surgery should be undertaken. In our experience the various local operations and gastro-enterostomy have given very satisfactory results.

Endeavoring to utilize the principles of the experimental work that has been done and to apply them clinically, I have employed direct anastomosis of the stomach and duodenum for the past several years. I have done this because it seemed to me that this operation left the structures so that they could function more in accord with the normal physiologic processes than would be possible if other procedures were used. The stomach and duodenum can be anastomosed much more readily than formerly was presumed possible. This operation has been employed particularly by Wilkie, in Edinburgh, and the results have been most encouraging. I have carried out such an anastomosis in many cases of duodenal ulcer and have reason to think that a new ulcer will not form in the duodenum subsequently. I realize that this is not in accord with the results obtained by some others. However, my experience has encouraged me to continue to employ the operation in selected cases. I have not carried out resection of the stomach for benign ulcer of the stomach and duodenum except under exceptional circumstances. Furthermore, it seems to me that I shall not be inclined to do so, as the experimental studies indicate that the principles involved in the treatment of gastric and duodenal ulcer do not support the contention that resection of the stomach is often required for solution of the problem of ulcer.

DR. ALTON OCHSNER (New Orleans, La.).—We, too, have attempted to evaluate the effect of acidity in experimental production of ulcer in three groups of experiments. We have attempted to reproduce ulcer in the stomach and the first portion of the intestine, as Doctor Dragstedt has done in a series of experiments.

In one series we formed pouches from the greater and lesser curvatures of the stomach, respectively. Although the acidity in the individual pouches varied but little, the incidence of ulcer was much higher (63.6 per cent) in the lesser curvature pouches than in those on the greater curvatures (0 per cent). Following histamine injections we also found the incidence of ulceration much greater along the lesser curvature than elsewhere in the stomach. This, we believe, is due to the fact that the "magenstrasse" is more susceptible to ulceration than other portions of the stomach.

In a second group of experiments the lesser and the greater curvature

pouches, respectively, were anastomosed with the proximal jejunum. Jejunal ulcers developed in all (100 per cent) of the animals with the greater curvature pouch-jejunal anastomosis, whereas but 71 per cent of the animals with lesser curvature pouch-jejunal anastomosis developed ulcers. In another group of animals with lesser and greater curvature pouches, respectively, and jejunal anastomoses, bile was diverted into the pouch by anastomosing the gallbladder to the pouch and dividing the common duct. The ulcer incidence decreased in the lesser curvature pouch-jejunal anastomosis to 50 per cent and in the greater curvature pouch-jejunal anastomosis to 28 per cent.

In further experiments performed by Doctor DeBakey, in our laboratory, the relative protective influences of bile, pancreatic, and duodenal juices were determined. Pyloric occlusion and gastrojejunostomies, similar to those advocated by von Eiselberg, were performed. Jejunal ulcers developed in 50 per cent of the animals. In addition to the pyloric occlusion operation the pancreatic juice was deviated away from the anastomotic site by anastomosing the pancreatic duct with the terminal ileum. The incidence of ulceration in this group was 70 per cent.

In another group the bile was deviated from the anastomotic site by anastomosing the gallbladder to the terminal ileum and dividing the common duct. Incidence of ulceration increased to 90 per cent. In animals with both the bile and pancreatic juice deviated from the anastomotic site the incidence of ulcer was 100 per cent. It may be concluded from these experiments that both bile and pancreatic juice are protective in preventing ulceration and that of the two bile is more protective than is pancreatic juice.

Based upon those experiments and our clinical observation, we feel that there are three factors in the production of peptic ulcer as follows: first, and probably the most important one from the standpoint of therapeutics, is increased acidity; second is tissue predisposition, and the lesser curvature of stomach is, as we all know, more susceptible to ulceration than other portions of the stomach. The third, and probably the most important etiologic factor is a predisposition to ulcer formation; *i.e.*, ulcer diathesis.

As regards therapy the best we can do is to control the acidity by diet and by the administration of antacids or by operation. All operative procedures should be of such a type as to decrease the acidity. We feel that in the patient with normal or hyperacidity gastro-enterostomy should not be done, because with the patient's ulcer diathesis the chances of developing a jejunal ulcer are even greater than developing the original ulcer, because the jejunal mucosa is less resistant to the acid gastric chyme than are the duodenal and gastric mucosa. A pyloroplasty which will permit regurgitation of the alkaline duodenal secretions more readily is much safer, but in some instances subtotal gastric resection will be necessary. From our experimental and clinical observations, however, we are convinced that the acceptance of the ulcer diathesis is essential and that for the life of the individual it is necessary for him to abstain from those things which increase gastric acidity, especially smoking and drinking of alcohol.

DR. HENRY F. GRAHAM (Brooklyn, N. Y.).—I would like to take exception to one statement made by Doctor Dragstedt, namely, the recommendation for a large opening in gastro-enterostomy. There are certain individuals who have a gastro-enterostomy, who are unable to eat large meals, especially those containing large quantities of fluid such as a dinner accompanied by soup and several glasses of water, without a great deal of discomfort and inability for

rapid emptying of the stomach afterward. I think there is a good mechanical reason for it.

If you have a large opening, and the stomach becomes distended, you get a flattening of the jejunum against the stomach and in that way it closes up the entire opening. I think it is possible to make too large an opening and thus cause trouble.

DR. J. SHELTON HORSLEY (Richmond, Va.).—It is quite necessary for surgery on any portion of the body, and especially on the stomach, to have a firm foundation on biologic facts. The observations of physiologists have taught us more about correct fundamental principles of gastric surgery than have the operating surgeons.

The etiology of peptic ulcers may be divided into three classes, or a combination of these classes: (1) hyperacidity, which Doctor Dragstedt has so well brought out; (2) toxic influences such as from burns or from certain types of streptococcic bacteria, which Rosenow has demonstrated; and (3) the neurogenic origin, which has been brought into prominence recently by Harvey Cushing. Doubtless in many instances some combination of these three causes may act to produce a peptic ulcer. The presence of hyperacidity, for instance, may be due to excessive vagus stimulation. The affinity of gastric cells for certain bacteria or toxic products may also cause hyperemia and probably hyperacidity.

An important fact that physiologists have shown is that the susceptibility of the gastro-intestinal mucosa to the acid of the gastric juice increases with the distance from the pylorus. Consequently, in a Billroth II type of gastrectomy, particularly if done for a gastric or duodenal ulcer with high acidity, we are apposing to the stomach a portion of the bowel that is more susceptible to irritation by the gastric juice than would be the duodenum. When the gastric acidity is low, as it usually is in cancer, the danger of jejunal ulcer is not so great, but it cannot be entirely eliminated for after the malignant lesion has been removed it may be that the acid secretion of the stomach will be resumed. That this is not solely a theory is shown by an interesting case reported by Dr. Fordyce B. St. John, of New York; he removed a cancer of the stomach and did a Billroth II type of operation. Later the patient died from a jejunal ulcer. It seems apparent that when a partial gastrectomy is indicated some type of Billroth I operation should be employed whenever it is possible to do so. There are ulcers in the duodenum not because the duodenum is more susceptible to the gastric juice, but because it receives the first impact of the acid.

Doctor Ochsner has shown in experiments that there is some protective influence of the bile against the formation of peptic gastric ulcers in experimental work on dogs, but this is not so great as the alkaline influence of the pancreatic juice. Bile is very slightly acid, or even neutral, whereas the pancreatic juice is very strongly alkaline. If the presence of bile, then, tends to lessen the incidence of peptic ulcer, it is probably due to some other cause than to its chemical reaction. In the interesting experiments of Doctor Ochsner a peptic ulcer occurred more frequently along the lesser curvature than the greater curvature. The factor of more active peristalsis along the lesser curvature than along the greater curvature should be taken into consideration. Peristalsis is initiated along the lesser curvature and ordinarily it is far more active in this region, whereas if the segment of the stomach comprising the greater curvature is isolated, much of the impulse for peristalsis has been obliterated. The more vigorous and constant action along the lesser curva-

ture, other things being equal, would seem to predispose to ulcer formation far more than in the quiet, inactive segment of the stomach.

DR. LESTER R. DRAGSTEDT (Chicago, Ill.).—It is not possible in the time allotted to give proper credit to the large amount of excellent experimental work on the cause of ulcer done both in this country and abroad. I should like to emphasize that there is nothing in our experiments which precludes the possibility that mechanical factors, such as the motility of the stomach or pylorus or the abrasive action of coarse food, or infection, may operate to delay the healing of an acute lesion and induce chronicity. However, I do believe that of all the factors likely to play a rôle in young and otherwise healthy adults (the people who get ulcers) the chemical action of the gastric content when it approaches the acidity of pure juice is the most important. The concentration of free hydrochloric acid is more significant than pepsin, and hence the term "acid ulcer" is more accurate than "peptic."

I am not convinced that the theory of Aschoff that the cause of prevalence of ulcer along the lesser curvature is the mechanical effect of food passing along the "canalis gastricus" is correct. We created such a canal experimentally in a dog with a large Pavlov pouch. The mucosa of the canal remained normal but an ulcer developed in the isolated pouch. There is no doubt that an acute lesion near the pylorus is more apt to become chronic than a similar one in the body of the stomach. We have a special case in the fact, I think, that such lesions produce spasm of the pylorus, cause retention, and so raise the acidity of the gastric content until it approaches the acidity of gastric juice. A pyloric lesion will do this to a normal secretory mechanism. There are other cases in which we find a hypersecretion of gastric juice, ill understood, perhaps, but without pyloric obstruction, and it is in these cases, I believe, that we find a large incidence of jejunal ulcer following operation, whether it be a gastro-enterostomy or partial resection.

The protective action of bile and pancreatic juice has been clearly demonstrated in experimental ulcer and has been of great significance in determining the importance of acid in the genesis of these lesions. This factor is of less importance in the clinical problem.

FACTORS GOVERNING THE RESULTS OF SURGICAL TREATMENT OF DUODENAL ULCER

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THE results of the surgical management of duodenal ulcer are always somewhat difficult to evaluate because of the many factors upon which they depend. Figures from various clinics show a convincing uniformity (80 to 90 per cent) of satisfactory results brought about by operation when chronicity and failure of adequate medical management are the basis for advising operation. When such a practice is followed, surgical treatment not only accomplishes relief of the symptoms of ulcer and marked general improvement in health, but a remarkable control against recurrence of the disease and protection against the most serious complication of ulcer, namely, acute perforation, as well as a high protection against subsequent hemorrhage. Although such results may be gratifying in view of the chronicity which is characteristic of the disease and the fact that all other treatment has failed before surgery is instituted, I believe that the continued study of the circumstances under which satisfactory results follow operation should provide clues which will aid toward a better understanding of the fact that the efficiency of surgical treatment primarily rests on the proper: (1) selection of cases for operation; and (2) selection of the operation. The more accurate our knowledge in these respects, the more accurate will be the prognosis as to what results may be expected from surgical management.

This study of 1,086 consecutive cases of chronic duodenal ulcer, in which patients were operated on in the years 1927 to 1928 and who have been followed over a period of seven years or more, was undertaken with the above mentioned purpose in view. It may be noted that although the results were compiled for a minimum of seven years after operation, they do not necessarily imply that recurrences of the disease or its complications after this time may not take place; but, when patients have been perfectly well for this length of time, serious recurrences are so rare that they are usually considered worthy of special record.

The results following operation have been classified as either satisfactory or poor. In the group in which results were satisfactory two general types of cases were included: (1) those in which patients were completely relieved of symptoms, and in which no restrictions in diet were necessary; there was no interference with work, and the patients were in excellent general health, such cases comprising approximately 90 per cent of those classified as satisfactory; and (2) the remaining 10 per cent of cases, in which there was persistence of symptoms, as represented by occasional discomfort which could be controlled by temporary care in the diet, alkalies, and by a better

balance of rest and activity. The group in which results were considered poor included cases in which the patients were not relieved of symptoms, continued to be more or less disabled, were unable to carry on a normal routine of living, and in whom jejunal ulcer developed or who had recurrence or reactivation of the ulcer necessitating continued treatment or further operation.

In reviewing these cases it is interesting to note the influence of age on the results, for it was found in the group of patients less than 30 years of age that satisfactory results followed in 85.2 per cent of cases, while those patients aged 60 years or more at the time of operation obtained a satisfactory result in 94.0 per cent of cases. The probable explanation for the better results obtained with older patients is: (1) that the lesion is likely to be more chronic than in younger patients; and (2) that with advancing years gastric secretion normally diminishes in activity.¹ In so far as recurrence of ulceration is concerned, jejunal ulcer developed following gastro-enterostomy in 5.3 per cent of cases in which patients were less than 30 years of age, and in 3.1 per cent of the cases in which they were more than 60 years of age.

The incidence of duodenal ulcer is lower among women than men; and possibly, because of whatever reasons make this true, the results of operation are also better among women than men. It was found that regardless of the type of operation carried out, a higher percentage of women (93.2 per cent) than men (86.0 per cent) obtained satisfactory results. The incidence of jejunal ulcer was 4.0 per cent among men, while there were no cases of jejunal ulcer in women (234 cases).

A study of the relationship of gastric acidity to the results of all operations disclosed the fact that when a constant high acidity, 70 or more, is present at the time of the operation, in 82.4 per cent of cases relief of symptoms may be expected. On the other hand, when the acidity is 30 or less, 90.5 per cent of patients obtained relief.

If results are considered on the basis of the effectiveness of the various types of operations as related to gastric acidity and the relationship of gastric acidity to the results of the operation, there appeared to be less evidence to justify radical views on this particular question than was anticipated. For example, it has long been thought that gastro-enterostomy should be avoided if possible for the group of patients with high acidity and no obstruction; but the fact that gastro-enterostomy brought about satisfactory results in 86.6 per cent of such cases, and that this is only a slightly lower percentage of satisfactory results than those that follow gastro-enterostomy when there is low acidity (89.2 per cent), suggests that too much emphasis has been given the contra-indications to gastro-enterostomy for the group with high acidity. It is true that the incidence of jejunal ulcer is higher for the group with high acidity as compared to the group with low acidity (4.4 to 2.7 per cent), but this fact does not give much support for the general replacement of gastro-enterostomy in the former group by plastic operations on the pyloric outlet or by

partial gastrectomy. In cases of excision and reconstruction of the pylorus, or gastroduodenostomy without excision, the avoidance of a 4.4 per cent risk of jejunal ulcer is counterbalanced both by the fact that the symptomatic results of these types of operations are considerably less satisfactory in this group than those following gastro-enterostomy, and also by the fact that the incidence of recurrence or reactivation of duodenal ulceration following the operations is much greater than the incidence of jejunal ulcer following gastro-enterostomy. It is in this high acid group that the advantages of partial gastrectomy have been most emphasized by the proponents of the operation. It has been our experience, however, that the higher the acidity, and consequently, theoretically, the greater the indications for partial gastrectomy, the more difficult it is to bring about sufficient control of the acid-forming mechanism to justify the operation on this basis. Many reports are now available from those who advocate wide gastric resection in such cases, showing that the persistence of acidity after radical resection is as high as 44 per cent.³ Moreover, recurrence of symptoms or of ulcer after partial gastrectomy is a much more serious problem with which to deal than that after gastro-enterostomy.

In studying the cases from the standpoint of complications prior to, or present at, operation, it was immediately obvious that because of the relief of the distress of an obstructed stomach, the most strikingly satisfactory results were obtained with those patients who had obstruction of the pylorus. The greater the obstruction the more positive the satisfactory results if any associated toxemia due to the obstruction was controlled, for then the risk of operation was low, even when the patient was in poor condition. In cases of very marked obstruction, the percentage of good results was 91.4 per cent.

The effect of gastro-enterostomy in cases of marked obstruction is well known, but a more important fact is that in the absence of obstruction, the satisfactory results following gastro-enterostomy over a minimum of seven years are only slightly lower, 89.7 per cent, than in cases in which the obstruction is marked, 91.4 per cent. The belief, therefore, that in cases without obstruction gastro-enterostomy should be avoided if possible, and that excision and reconstruction of the pyloric outlet should be chosen, has not been substantiated in this study. This last named procedure under such circumstances was followed by 80.4 per cent satisfactory results as contrasted with 89.7 per cent following gastro-enterostomy. As for gastric resection in this group, reports are not available as to the control of symptoms over a similar length of time after operation, but thus far it has been shown from certain continental clinics that there are persisting symptoms in between 10 to 20 per cent of cases.

It is difficult to evaluate the relationship of chronic and subacute perforation to results, since this complication varies so much in degree. However, the impression that better results were obtained in those cases in which extensive induration had occurred about the duodenum seemed to be borne out by this investigation. Possibly the greater severity of symptoms in cases of extensive perforation, and therefore the marked relief from these symptoms, may have been partly responsible for such an impression.

Hemorrhage from ulcer continues to present a most difficult surgical problem. It should be emphasized that in cases of hemorrhagic peptic ulcer, the mortality from hemorrhage itself has recently been shown to be considerably higher than was formerly thought. Statistics from various hospitals² have shown that the complication not only is a serious one, but not infrequently one that has a fatal outcome. A study of cases of hemorrhagic ulcer emphasizes the difficulty in evaluating the effect of the different forms of surgical management, since hemorrhage varies so in frequency, severity, and in the extent to which it is associated with other symptoms of ulcer. In this group of 1,086 cases studied, one or more hemorrhages had occurred prior to operation in 22.7 per cent of cases, and, judging by the history, the hemorrhagic character of the lesion was a considerable factor in advising operation. It has been stated, a supposition to which we have subscribed at the clinic, that protection against subsequent hemorrhage was greater if the lesion or lesions could be removed; but in this group of cases this was not substantiated, for it was found that the indirect operations afforded at least equal protection against recurrence of hemorrhage as do those operations which include a direct attack on the ulcer.

The explanation of this apparent discrepancy between good theory and actual practice is related to some extent to the fact that a satisfactory gastro-enterostomy brings about and maintains healing of single and multiple inflammatory processes in the duodenum, and that any recurrence of bleeding usually is due to a superficial erosion which heals readily because of the gastro-enterostomy.

Although excision of the lesion and reconstruction of the pyloric outlet, or gastric resection of the Billroth I type, for hemorrhagic ulcer are theoretically and physiologically sound, these operations do not give as great protection against subsequent hemorrhage as do gastro-enterostomy or partial gastrectomy by the Billroth II method or its modifications. This probably is due to two facts: (1) that the former procedures do not always permit satisfactory excision of small concealed lesions; and (2) maintaining continuity of the stomach and duodenum apparently carries with it certain disadvantages in respect to reactivation and recurrence of inflammatory processes. The incidence of jejunal ulcer is so small when gastro-enterostomy is carried out on proper indications that excision and reconstruction, done primarily to avoid jejunal ulcer in these cases of hemorrhage, are not justified except in those in which the liability to jejunal ulcer is known to be high because of conditions already suggested.

In the Billroth II type of operation, any recurrence of hemorrhage almost certainly is caused by jejunal ulcer or jejunitis, since complete exclusion of the duodenum itself is extremely rarely followed by reactivation of any unremoved lesion in the duodenum or development of a new lesion at that site.

In spite of the fact that gastro-enterostomy by actual figures seems to be almost as effectual a means of protection in bleeding types of duodenal ulcer, theoretically the Billroth II operation, or one of its modifications, would give

the fewest recurrences. However, the Billroth II operation has the disadvantages of a much higher primary risk (particularly if a thorough resection is done of the involved part of the duodenum) and of failing to protect absolutely against recurrence of ulceration. Such facts will always emphasize the advantages of conservative procedures. In view of the information derived from this group of cases it would seem that the most reasonable management of the bleeding type of duodenal ulcer would be thorough local excision, if feasible, combined with a large gastro-enterostomy.

If the data obtained from this study are correlated, it is apparent that, in general, the best results, in so far as relief of symptoms is concerned, are obtained for patients (particularly women) of middle age, with impaired motor function, low acidity, and a long standing history of distress. Less satisfactory results are obtained, regardless of operation, the farther conditions are in opposition to the factors above mentioned; but this particular series of cases gives surprisingly little emphasis to this point. In respect to the value of the different types of operations, this study showed conclusively that if results are computed over a sufficient length of time after operation, and surgical management has been well applied according to the circumstances in each case, the conservative operations present so many advantages that they are the operations of choice for chronic duodenal ulcer, both with and without complications. In particular, the value of gastro-enterostomy clearly is apparent, for not only does it usually bring about complete and permanent healing of duodenal ulcer, but in the event of recurrence of ulceration in the stomach or jejunum it is the only operation which permits restoration of normal continuity of the stomach and duodenum, an advantage which it is unnecessary to emphasize.

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THE POSSIBILITY OF MALIGNANCY AS IT AFFECTS THE TREATMENT OF CHRONIC GASTRIC ULCER

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THE chronic ulcer in the stomach may prove to be malignant, thereby differing significantly from the similar lesion in the duodenum. This is no newly discovered fact but has long been common knowledge. Its practical implications for treatment, however, are almost universally neglected. The history, the physical findings, all laboratory tests, the roentgenographic examination, the appearance at operation, even occasionally the histologic section may fail to differentiate the benign from the malignant ulcer of the stomach. There has been a controversy extending now over more than 50 years as to whether such malignant ulcers masquerading as benign in appearance usually arise as the degeneration of a preexisting, benign ulceration, or are carcinomata from their inception.¹ In 1927, I reviewed the evidence in the literature concerning this relationship of carcinoma and callous gastric ulcer² and concluded that the important point for the clinician and for the patient was not the academic one, which had been chiefly debated, as to what percentage of benign ulcers become malignant, but was the very practical one that many of the lesions which appeared clinically as simple ulcers proved eventually to be malignant. Refined methods of study, particularly the more exact investigation of the secretory activities of the stomach³ and refinements in roentgenographic examination of the gastric pattern and activity,^{4, 5} still fail to solve this problem in differential diagnosis. Thus Gray and Balfour,⁶ in studying a large group of resected carcinomata, report that in 30 per cent of cases the roentgenologist had been unable to decide that the lesion was malignant and in ten per cent more had called it benign. In spite of an intensive search for some method of demonstrating when an ulcer is malignant, it is admitted almost universally by all competent clinicians that there is no such absolute criterion available. Consequently the individual instance of chronic gastric ulcer should be regarded at first as a possible malignancy no matter how long the history nor how benign the appearance of the lesion. Let me illustrate this diagnostic difficulty with three cases.

CASE REPORTS

CASE I.—C.H.B. SMH. 4368. Male, aged 66, had had typical ulcer pain for 12 years always relieved by food and soda. In his last exacerbation of symptoms (two months) the pain has come a little sooner after eating but otherwise has been the same. No weight loss. P.E.—Negative. Lab.—Gastric analysis: Fasting, 18 per cent free HCl, 46 per cent total; increased to 52 per cent free and 76 per cent total after Ewald test meal. Stool—guaiac negative. Hemoglobin, 80 per cent.

MALIGNANCY AND GASTRIC ULCER

Roentgenologic examination.—Typical penetrating ulcer niche $1\frac{1}{2}$ cm. broad and 1 cm. deep sharply outlined on the lesser curvature at the angulus.

Preoperative and postoperative diagnosis.—Chronic gastric ulcer. Nothing to suggest malignancy.

Operation.—Subtotal gastrectomy.

Histology.—Showed typical appearance of benign ulcer with scar tissue base separating the muscularis without any evidence of malignancy in sections through the center of the ulcer. In one section at the edge of the ulcer there is typical adenocarcinoma extending from the mucous membrane and invading the muscularis and a limited small area of the scar tissue base at that one point only.

This case was reported in detail together with the histologic evidence in Surg., Gynec. and Obst., vol. 46, p. 199, 1928. It is apparently a typical example of carcinoma developing in the edge of a preexistent benign ulcer. Nothing in either the clinical data or laboratory and roentgenologic studies suggested the presence of malignancy. The patient has remained entirely free of gastro-intestinal symptoms and without evidence of recurrence, now over eight years.

CASE II.—F.T.F. SMH 63871. Female, aged 46. P.I.—Typical ulcer pain, two to three hours after meals together with persistent night pain; six months' duration. P.E.—Tenderness over the pyloric region. Lab.—Red blood cells, 4 mil. hemoglobin, 75 per cent. Gastric analysis—not done on account of lack of cooperation of the patient. Stool—guaiac negative.

Roentgenologic examination.—G. I. series showed irregularity of the cap with local tenderness over it.

Course.—Day pain cleared up quickly on Sippy regimen. Night pain disappeared more gradually, following which the patient was discharged from the hospital. Pain recurred on an ambulatory ulcer regimen in two months and on this account she was readmitted to the hospital for operation.

Preoperative diagnosis.—Duodenal ulcer. Postoperative diagnosis.—Gastric ulcer.

Operation.—The ulcer proved to be on the gastric side of the pylorus, was 1.5 cm. in diameter, sharply circumscribed and non-indurated. The ulcer seemed so innocuous the surgeon operating was sure it was benign. Consequently he excised the ulcer with a liberal wedge and posterior gastro-enterostomy was performed. The lesion proved microscopically to be malignant in spite of its non-indurated character. The patient was strongly advised to be reoperated upon but subtotal gastrectomy was refused. She had an obvious recurrence in the epigastrium, which was verified on exploration 13 months after the first operation.

CASE III.—P.W. SMH 21096. Male, aged 21. First seen in 1929 with rather vague ulcer pain and roentgenologic evidence not conclusive but suggesting duodenal ulcer. He was at that time put on an ulcer diet and promptly became free from symptoms. He was readmitted in December, 1931, with the characteristic history and physical evidence of a ruptured ulcer.

Preoperative diagnosis.—Ruptured ulcer, probably duodenal.

Operation.—Ulcer was found on the lesser curvature of the stomach about one inch proximal to the pylorus. It showed a free perforation about one cm. in diameter with the indurated area sharply circumscribed to the region of the ulcer. It was closed by inversion. The operator entertained no question that the ulcer was anything but benign.

Course.—Symptomatic relief for two years followed by recurrence of moderate ulcer pain and occasional vomiting not of sufficient severity to bring the patient back to the clinic. Readmitted (second time) in January, 1934, on account of major hemorrhage from the ulcer (melena). Red blood cells had fallen to 3.4 mil. The patient had no pain and rapidly regenerated his blood on a conservative regimen.

Operation.—One month after hemorrhage subtotal gastrectomy was carried out. The scar of the perforated ulcer was identified at operation by the black silk sutures encapsulated in its peritoneal surface. Continuous with this healed scar, extending downward

on the posterior surface, was an ulcerated area about 3 cm. in diameter surrounded by a larger zone of induration (Fig. 1). While there was nothing pathognomonic about the ulcer, its size and the extent of the induration about it suggested the possibility of malignancy. Microscopically the ulcer was definitely malignant though the scarred area which had originally perforated was uninvolved.

These examples are chosen from a number of others that would equally well illustrate the impossibility of differentiating certain malignancies from benign chronic gastric ulcers on the basis of clinical examination, laboratory findings, or roentgenologic studies. On the other hand, however, many gastric ulcers respond favorably to medical treatment and never require operation. In order to harmonize, for therapy, these two conflicting tendencies in gastric ulcer, it was necessary to develop a clinical test for malignancy. Following the method of Jordan and Lahey⁷ those gastric ulcers not having definite malignant stigmata are satisfactorily divided into two main groups by their response to a short period of medical treatment.

CHART I.

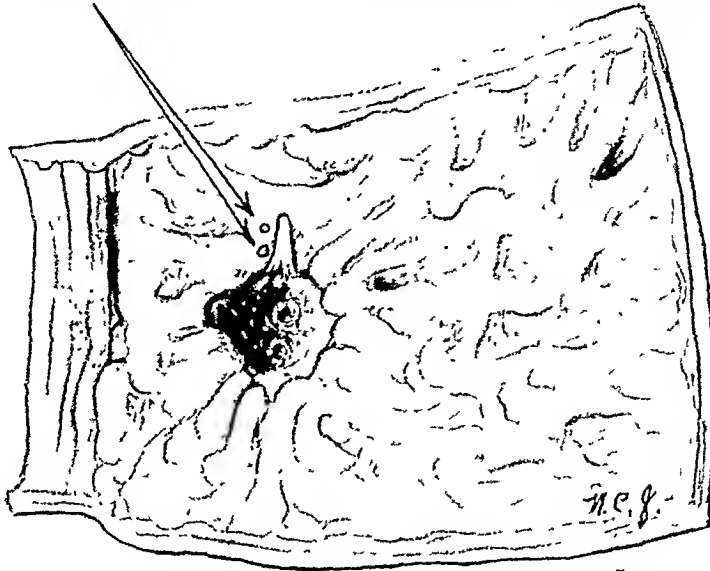
CLINICAL TEST FOR MALIGNANCY IN CHRONIC GASTRIC ULCER

By response to rigid medical treatment			
Within		Group A	Group B
1 week	Improvement in symptoms	+	—
2 "	Practical disappearance of symptoms	+	—
2 "	Disappearance of occult blood in stools	+	—
3 "	Marked decrease in size of ulcer niche (at least $\frac{1}{3}$)	+	—
After 3 weeks	Continuous decrease of ulcer to disappearance (checked by X-ray)	+	—
Any time on treatment }	Recurrence of symptoms or Increase in ulcer niche		+

By the use of this clinical test for malignancy, the gastric ulcers are divided into two groups at the end of not over three weeks' time. These do not represent complete separation of pathologic entities but they serve as a basis for the choice of therapy. In the first group where the response to the test is not only by symptomatic relief but also by marked decrease in the size of the lesion, medical treatment should be continued, checked carefully, however, by roentgenologic studies, until it is proved that the niche has completely disappeared. The patients in the second group where the response is unsatisfactory or incomplete should be operated upon at once (Chart I).

The two following cases illustrate the typical difference in reaction of two examples, one falling in each of the groups. The cases originally were very similar, both in the cancer age, the location, size and appearance of the niche being not unlike, and neither had free HCl in the fasting contents but both showed it after an alcohol test meal. Yet the response of these two cases was entirely dissimilar and indicated in the one case the continuation of medical

Location of silk ties on peritoneal surface



Section of stomach

1 cm. 2

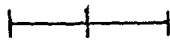


FIG. 1.—Case III. P. W.—Appearance of ulcer at resection. The position on the peritoneal surface of the silk ligature marking the site of the ruptured ulcer two years previously is indicated on the drawing. At the first operation there was nothing to suggest malignancy.

treatment, in the other immediate radical surgery which has given this patient a chance for cure of a carcinomatous ulcer.

CASE REPORTS

CASE IV.—R.S. SMH 96388. Male, aged 50. Typical ulcer pain coming two hours after meals associated with black stools; duration three weeks. Ten pound weight loss. P.E.—Moderate emaciation, tenderness on deep pressure in midepigastrium. Lab.—Red blood cells, 3.5 mil. Stool—guaiac negative. Gastric analysis, fasting, 0 free HCl, 22 per cent total. After alcohol test meal, 20 per cent free HCl, 36 per cent total.

Roentgenologic examination.—Large ulcer niche (3 cm.) high on lesser curvature (Fig. 2).

Preliminary diagnosis.—Gastric ulcer, possibly malignant.

Course.—Satisfactory response to test period of medical treatment (Figs. 3 and 4). Asymptomatic on ambulatory ulcer regimen at present.

CASE V.—C.A. SMH 85305. Male, aged 62. P.I.—Typical ulcer pain three to four hours after meals completely relieved by soda, incompletely by food; duration seven months. P. E.—No abdominal masses or tenderness. Lab.—Gastric analysis—fasting contents no free HCl, after alcohol test meal free HCl present. Stool—guaiac negative.



FIG. 2.—Case IV. R. S.—Large ulcer niche on lesser curvature.

Roentgenologic examination.—Large ulcer (3 cm.) on lesser curvature of stomach (Fig. 5).

Course.—Ambulatory ulcer diet prescribed at first visit in out-patient department (before the roentgenologic examination had been obtained), gave complete symptomatic relief within five days. On repeating the roentgenography at the end of three weeks,



FIG. 3.—Case IV. R. S.—Significant decrease in size three weeks later.

FIG. 4.—Case IV. R. S.—Complete disappearance of niche six weeks later than Fig. 3



FIG. 5.—Case V. C. A.—Large ulcer niche at angulus on lesser curvature. No striking decrease in size after three weeks in spite of complete symptomatic relief.

however, there was no significant decrease in the size of the niche. Consequently this patient falls in Group II and prompt operation was urged upon the patient. Due to the fact that the patient was symptom-free, he resisted this advice, but through pressure on the patient through the family, operation was accepted.

Preoperative diagnosis.—Gastric ulcer, probably malignant.

Operation.—Subtotal gastrectomy. Grossly the lesion was an ulcer, not certainly malignant (Fig. 6). Microscopic examination showed a carcinomatous ulcer. The patient is now symptom-free one year after operation.

Thus the clinical test saves us from operating for lesions that respond like that in Case IV. In most such patients, ulcer symptoms will continue to be held in abeyance and on repeated roentgenologic examination the appearance of the stomach will be found to be normal. Probably such lesions are represented by the healed small scarred areas covered with thinner epithelium that have been reported as found repeatedly in the stomach during routine autopsy examinations. Occasionally symptoms will recur during treatment in one of these cases that originally responded satisfactorily. The lesion then immediately becomes a carcinoma suspect and is treated as such. In the sec-

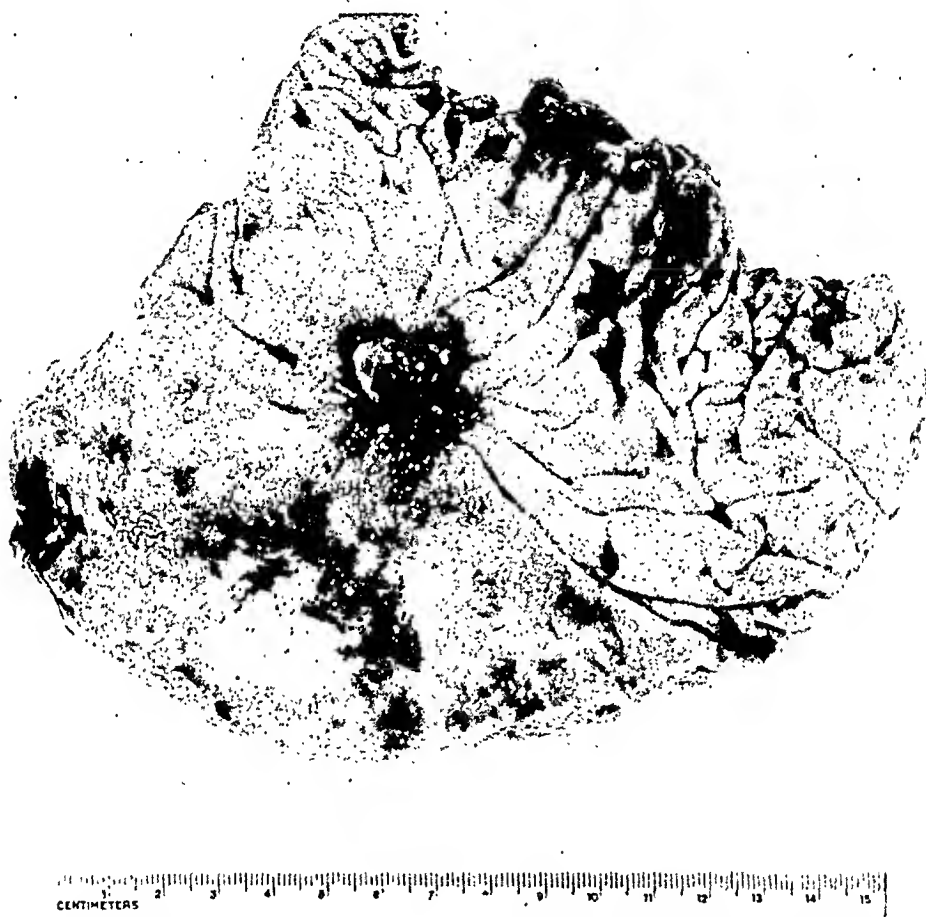


FIG. 6.—Appearance of ulcer on resection; no definite evidence of malignancy grossly.

ond group where the response to treatment is unsatisfactory or incomplete either symptomatically or by roentgenologic examination, many, though not all, of the lesions will prove histologically to be malignant. For this reason we treat radically the lesions in the second group, carrying out subtotal gastrectomy no matter how innocent such an ulcer may appear at operation. The local excision of these ulcers without including the lymph node bearing area is irrational and in our experience has usually resulted in recurrence when the ulcer proved to be malignant, as in Case II. We are convinced that the chronic gastric ulcer in the stomach chosen for operation on the basis of its incomplete response to a short trial period of medical treatment should be dealt with exactly as if it were known to be carcinomatous.

The second major way in which the possibility of malignancy should affect the treatment of gastric ulcer is in the opposite direction. It has been well established that the large gastric ulcer over two and one-half to three cm. in diameter is particularly likely to be malignant.⁸ Although the exponents of this proposition never claimed more than a high degree of probability for it, many clinicians, in fact most of us, when confronted in the consulting room or at the operating table by a huge callous gastric ulcer, automatically tend to assume that there is little chance of its being benign. In our material of over 200 cases presenting themselves clinically as ulcers, the differentiation between a malignant and a benign lesion frequently has proved equally impossible in the very large ulcer as it has in the case of the smaller lesion. The practical corollary of this fact is that too pessimistic a view of the nature of the lesion is unwarranted on the basis of size until malignancy is proved under the microscope. I should like to offer the evidence of the following cases in support of this statement.

CASE REPORTS

CASE VI.—A. deM. SMH 36881. Male, aged 46. P.I.—Typical ulcer pain eight years' duration. Melena with symptoms twice during this time. Forty pound weight loss in the last year. P.E.—Emaciation, visible peristalsis over stomach. Lab.—Red blood cells, 4.5 mil. Hemoglobin, 85 per cent. Stool—guaiac negative.

Roentgenologic examination.—Huge ulcer niche high on lesser curvature of the stomach with formation of an accessory pocket (3½ cm. across the neck of the defect, 5½ cm. across the widest point) (Fig. 7).



FIG. 7.—Case VI. A. deM.—Huge ulcer high on greater curvature.

Course.—Favorable response to treatment with reduction of the enormous defect to a minute "V" shaped one with relief of symptoms for five months (Figs. 8, 9 and 10). Recurrence of symptoms and increase in the niche (Fig. 11).

Preoperative diagnosis.—Gastric ulcer, benign, probably with adherent ulcer base.

Operation.—Subtotal gastrectomy. Ulcer base found adherent to liver and pancreas. Microscopic examination showed a benign gastric ulcer.

Course.—Symptom-free since operation four years ago.

CASE VII.—A.B. SMH 64199 Male, aged 53. P.I.—Ulcer pain with

relief by food and soda—three years' duration. Questionable hematemesis once. Questionable melena several times. Attacks of vomiting. P.E.—Moderate emaciation. Point tenderness right epigastrium. Lab.—Red blood cells, 4.5 mil. Stool—guaiac positive. Gastric analysis—fasting; no free HCl, 25 per cent total. After histamine; 70 per cent free, 92 per cent total.

Roentgenologic examination.—90 per cent six hour gastric residue. Large ulcer niche on lesser curvature (3 cm. in diameter).

Preoperative diagnosis.—Gastric ulcer—questionably malignant.

Operation.—Subtotal gastrectomy. Induration extended down from the ulcer to

involve the pylorus. While the lesion grossly suggested malignancy, the histologic sections did not bear this out. The patient was symptom-free at last report a year after operation.

CASE VIII.—J.T. SMH 76173. Male, aged 52. P.I.—Ulcer pain five weeks' duration. No symptomatic relief from strict medical regimen in bed. Two episodes of similar pain 15 and 30 years ago. P.E.—Tenderness in epigastrium. Lab.—Hemoglobin, 95 per cent. Stool—guaiac strongly positive. Gastric analysis—fasting, 18 per cent HCl, 33 per cent total.



FIG 8.—Case VI. A. deM.—Marked reduction in size after two weeks' treatment.



FIG. 9—Case VI. A. deM.—Size after four weeks' treatment.

Roentgenologic examination.—Moderate six hour residue with large flat ulcer niche (4 cm) on lesser curvature of the stomach at the angulus (Fig. 12).

Preoperative diagnosis.—Gastric ulcer—probably malignant.

Operation.—Subtotal gastrectomy. At operation the lesion was thought to be probably malignant but histologic section showed it to be benign. Patient has been asymptomatic since operation.

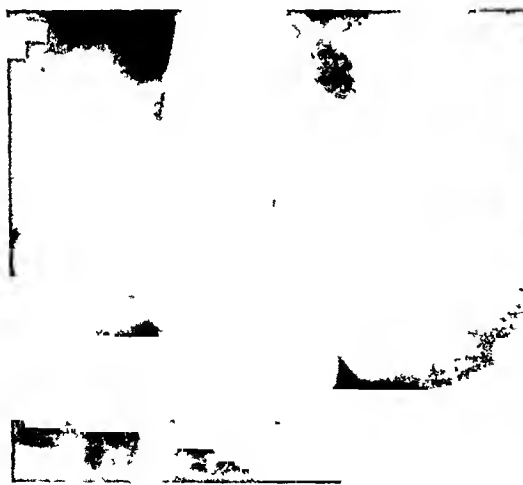


FIG 10.—Case VI. A. deM.—Six weeks after treatment the niche had been reduced to a small "V."



FIG 11.—Case VI. A. deM.—Six months later than Fig. 10 while still on treatment the small "V" shaped defect began to become dumb-bell shaped again with the recurrence of ulcer symptoms. Resection was easily carried out in this stage before the ulcer had become large again.

CASE IX.—G.W. SMH 28218. Male, aged 55. P.I.—Gastric obstructive symptoms with pain unrelieved by food or soda; five months' duration. Recent vomiting with

coffee ground material. P E.—Tenderness and mass in right epigastrium. Lab.—Hemoglobin 95 per cent Stool—tarry, guaiac positive. Vomitus—guaiac positive with free HCl.

Roentgenologic examination.—One-third residue at six hours Irregularity in outline of pyloric end of stomach

Preoperative diagnosis.—Carcinoma of stomach.

Operation.—Subtotal gastrectomy. A very large ulcer occupied practically the whole



FIG. 12.—Case VIII. J. T.—Large flat ulcer niche on lesser curvature extending on to the posterior wall of the stomach.

of the posterior wall in the pyloric end of the stomach past the angulus (Fig. 13). In spite of its tremendous size, sections taken from all parts of this lesion failed to show any carcinoma. The patient has remained free of symptoms since operation six years ago.

CASE X.—W.C. SMH 65255. Male, aged 55. P.I.—Pain in left epigastrium

three and one-half years' duration. This has almost completely incapacitated him for one and one-half years. No relief of pain on ulcer regimen. Major hemorrhage (hematemesis and melena), hemoglobin, 44 per cent. Thirty pound weight loss. P.E.—Emaciation. Tenderness in midepigastrium.

Lab.—Hemoglobin, 90 per cent. Stool—benzidin negative. Gastric analysis—fasting; no free HCl, 13 per cent total. After alcohol test meal; no free, 18 per cent total. After histamine; 32 per cent free, 48 per cent total.

Roentgenologic examination.—Huge deforming ulcer on posterior wall of the cardiac end of the stomach (5 by 3½ cm.), the deformity reaching the greater curvature (Fig. 14).

Preliminary diagnosis.—Gastric ulcer—questionably malignant.

Operation.—Gastrectomy.—(two stage) with anastomosis of the esophagus to the jejunum. The operation was carried out in two stages, the amount of induration (into the pancreas) with the enlargement of the lymph nodes along the aorta and about the cardia made it seem almost certain that the lesion was malignant. Biopsy of one of these nodes

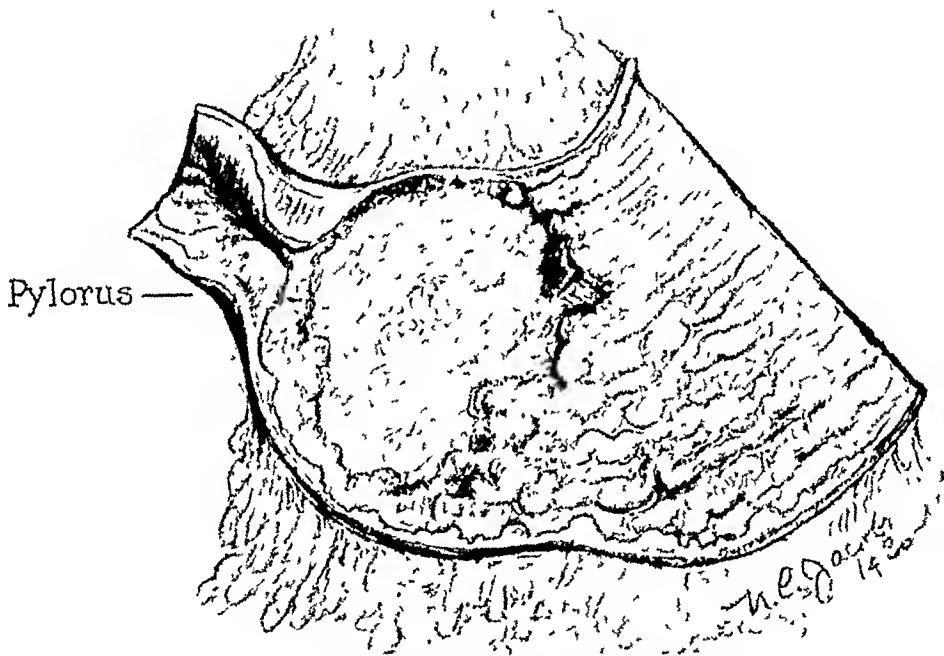


FIG. 13.—Case IX. G. W.—Huge ulcer involving nearly all of the posterior wall of the pyloric antrum

removed in the first stage was not found to contain cancer. Consequently the lesion was removed at a second stage with an excellent exposure of the cardia by chondroplastic resection of the costal margin. All of the stomach was removed except the pylorus and prepyloric antrum. The patient has been free from symptoms since operation (three years).

It seems, then, that many chronic gastric ulcers which by their size and other clinical characteristics suggest malignancy are found actually to be benign lesions. The lesson for the surgeon in this is that radical cure of these large ulcers when they do not respond to medical treatment should be attempted if definite evidence of metastasis or extension is lacking.

DISCUSSION

Case I is definitely carcinoma *ex ulcere* and apparently Case III is also a malignant ulcer which developed as the direct continuation from a perforated benign ulcer. We do not have evidence of the histologic structure of this ulcer at the time of perforation, but it healed with normal scar for-

mation and without carcinoma in its base. This is the only ulcer in our series which perforated freely, at operation appearing to be a simple benign perforated ulcer, but which subsequently developed the characteristics of malignancy. Usually we consider the punched-out simple perforated ulcer as a benign lesion both at the time of operation and also in its potentialities. We do not resect such lesions. This case demonstrates, however, that even such apparently benign lesions have to be kept under observation for malignancy. It was only in conformity with our rule that all gastric ulcers are treated by radical resection if symptoms recur that this patient was operated upon after he had recovered from the immediate effects of hemorrhage.

The second case is an excellent illustration of the prepyloric ulcer. Upon roentgenologic examination on two occasions this lesion was considered to be on the duodenal side of the pylorus due to the absence of any characteristic niche and the presence of a persistent irregularity of the duodenal cap. On finding the ulcer on the gastric side of the pylorus, the surgeon should have been warned of the possibility of malignancy in spite of the benign appearance of the small ulcer. Holmes and Hampton⁹ have recently stressed the fact that the vast majority of the ulcers proximal to the pyloric canal but within about one inch of it are malignant. Finsterer¹⁰ has also urged that such prepyloric ulcers should receive special attention. In addition this case illustrates how unsatisfactory is local excision of the ulcer. Possibly the same rapid recurrence would have followed subtotal gastrectomy in this case, but at least we could feel that everything possible had been done for the patient. Our rule in regard to resection by subtotal gastrectomy was broken in this case because the operating surgeon was so sure that the ulcer was not malignant. Particularly in the prepyloric region, this rule should never be broken because the lesion looks innocent.

In regard to the use of a trial period of treatment, we adopted this procedure in order to avoid operation in those cases that respond well to medical treatment. Symptomatic relief alone, however, is by no means a satisfactory guide but must be accompanied by a striking decrease in the size of the ulcer niche as demonstrated by roentgenologic examination. This fact cannot be too strongly emphasized and is not sufficiently recognized. A recent author,¹¹ in summarizing the clinical considerations of gastric ulcer and carcinoma, stated "in early carcinoma, medical treatment rarely abolishes pain." This is distinctly not in agreement with our experience in the early cases and we feel sure that if symptomatic relief alone is used as a criterion, many patients with malignant ulcers will be thought to respond satisfactorily. For example, Case V on an ambulatory dietary treatment was completely relieved of pain before his roentgenologic studies were available at his second visit (five days after starting treatment). Patients with frank carcinoma producing a large filling defect often get symptomatic relief for several weeks and may gain as much as 25 pounds in weight when put on an ulcer regimen. Such dependence on the symptomatic effect of treatment for its guidance has been one of the important factors in delaying the earliest possible resection of ulcer-mimicking

carcinomata of the stomach. Some surgeons find fault with a trial period of treatment as causing a delay in operating on those ulcers which prove after resection to be malignant. In 1927 we advised operation for all callous gastric ulcers.² Such a policy, however, is too drastic as it submits to operation many ulcers that will respond satisfactorily to medical treatment. We still advise *immediate* operation for all ulcers in the stomach which present strongly suggestive evidence that the lesion is malignant. However, the size of the ulcer alone, the absence of free hydrochloric acid, the association of pyloric obstruction, moderate loss of weight and strength, are not in themselves such criteria of malignancy as they are found in many benign ulcers. The prepyloric ulcer, the ulcer on the greater curvature of the stomach and the ulcer showing roentgenologic characteristics of malignancy⁵ should be explored immediately without being submitted to such a test period. Ulcers on the lesser curvature of the stomach which have not been given a brief trial of medical treatment, however, should have this test. Usually the period need not be over three weeks in length; often it may be considerably less than this. In the by and large, if we could get the whole medical profession to carry out such a clinical trial at the first moment when they see a new case of gastric ulcer, we would save, on the average, many weeks of valuable time in arriving at operation in these carcinomatous ulcers.

Case VI illustrates very well the diagnostic import of the accessory pocket in the ulcer niche. Carman¹² called attention to the fact that no matter how large an ulcer niche is, when it perforates the stomach wall with the formation of an accessory pocket the lesion is seldom malignant. An ulcerating carcinoma often breaks through the gastric wall and may attach itself to adjacent tissues but in such a situation usually a filling defect or irregularity in the vicinity of the ulcer margin suggests the presence of neoplasm.

Whipple and Raiford¹³ have given us an important correlation between the gross tumor type and the prognosis in gastric carcinoma. They make the point that malignant lesions with an ulcer story followed by a change in the symptoms are usually of the infiltrating, highly malignant type and therefore operation is indicated at once. Consequently it is very important to detect the character of these lesions before they have reached this stage. I believe that the management outlined for ulcers which fail to respond completely to a short test period of medical treatment or whose symptoms recur on treatment will call attention to such lesions in the earliest possible stage.

Some who still doubt the frequency and importance of malignant ulcers in the stomach, clinically indistinguishable from benign lesions, point to results such as those reported by Balfour,¹⁴ following gastro-enterostomy without removal of the lesion. He found in 100 cases, where the ulcer was not removed and the patient was followed for five years or more, only six instances of death from gastric carcinoma. On analyzing these results, however, in the light of the selection of these patients as explained by Balfour, it is apparent that the method of choice automatically included those lesions, chiefly from the posterior wall of the stomach, the upper half of the lesser

curvature and the cardiac end of the stomach where the proportion of malignant ulcers is particularly low and excluded ulcers of the pyloric antrum and the greater curvature, locations where there is a greater likelihood of malignancy among questionable lesions. Therefore by this process of selection, an incidence of 6 per cent of carcinoma is not surprising at all.

The last case illustrates a technical maneuver of some value in approaching the cardiac end of the stomach. When the costal angle is relatively narrow, it may be very difficult indeed to expose the cardia of the stomach. By carrying out chondroplastic resection of the costal margin (Figs. 15 and 16), an excellent exposure of the cardia is obtained. This method of exposure of structures just beneath the left diaphragm was first reported in this country by



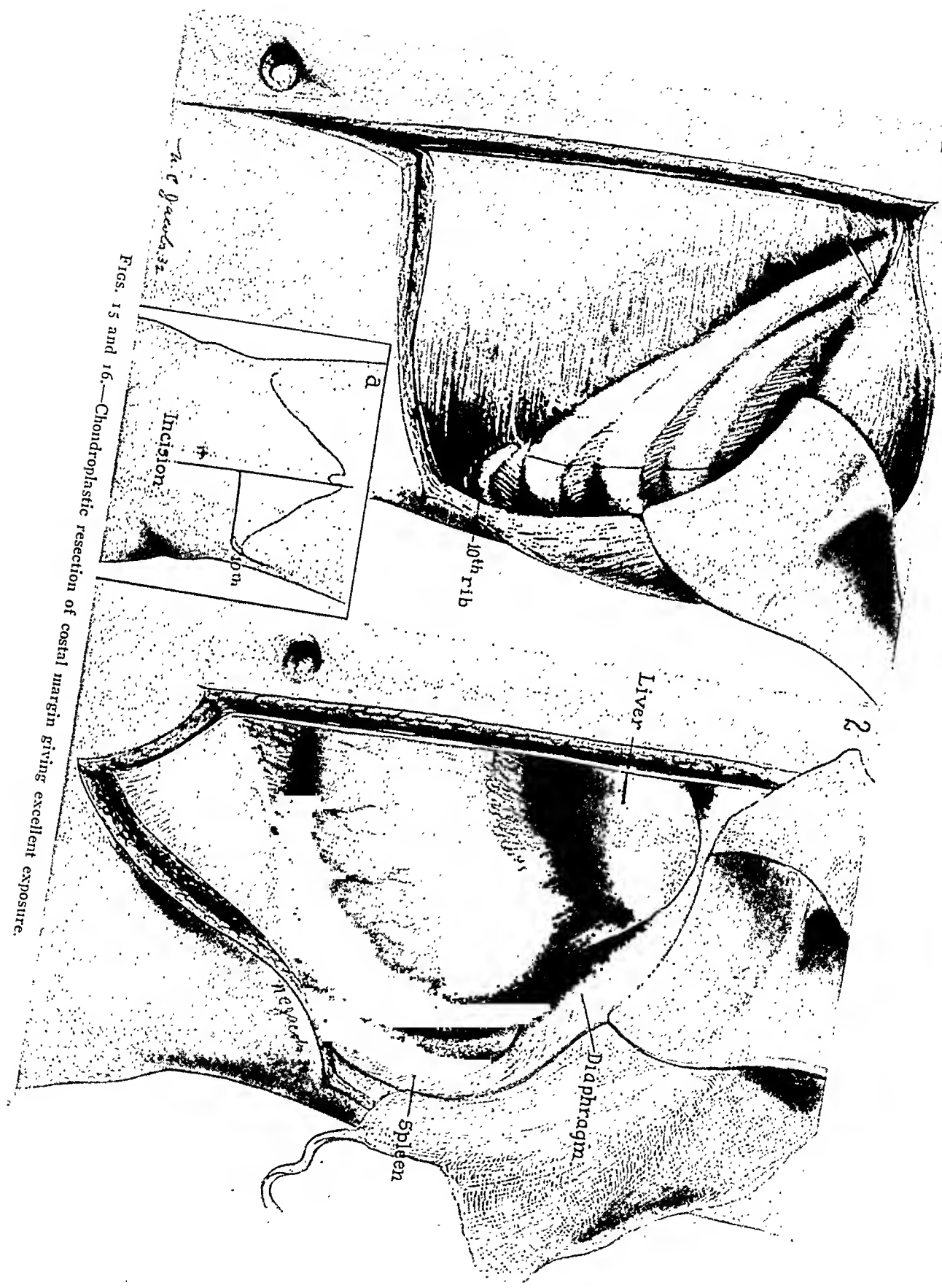
FIG. 14 —Case X. W. C—Huge deforming ulcer on the posterior wall of the cardiac end of the stomach reaching the greater curvature

Willy Meyer, Sr.,¹⁵ in 1906, and has recently been made readily available in the literature by his son.¹⁶ It was of very real technical advantage to us in this case and enabled us to remove with comparative ease a lesion the exposure of which would have been extremely difficult without its aid.

CONCLUSIONS

It is impossible to differentiate with certainty between many of the malignant and the benign ulcers in the stomach. This fact has two practical implications for treatment: (1) unless a gastric ulcer responds promptly and completely to a therapeutic test period, not only by symptomatic relief but also in the size of the roentgenographic niche, it should be removed at once in the same radical manner that known carcinoma is treated, *i.e.*, ordinarily by subtotal gastrectomy. (2) Huge gastric ulcers showing no other stigmata of malignancy are frequently benign, and, if refractory to a short test period of medical treatment, they should be attacked surgically for cure.

MALIGNANCY AND GASTRIC ULCER



—H. C. Quack, Jr.

Figs. 15 and 16.—Chondroplastic resection of costal margin giving excellent exposure.

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DISCUSSION.—DR. E. STARR JUDD (Rochester, Minn.).—I think we all agree with Doctor Scott that experience has taught that there is no certain method of distinguishing benign from malignant gastric ulcer either before operation or from the gross appearance of the lesion at operation. With present methods of investigation it is usually not difficult to arrive at a diagnosis of "carcinoma or ulcer," but to distinguish between these two conditions, and to divide the cases into the two groups, is the difficult and important problem.

In order to determine whether there might be any diagnostic criteria that could be relied on to distinguish benign from malignant gastric lesions, Rivers and Dry made a careful comparative clinical study of the laboratory data in 100 cases of benign gastric ulcer and in 100 cases of malignant gastric ulcer. Evaluation of the information available in the histories of these cases corroborates the impression that some features suggest the probability that certain lesions are benign and that others are malignant.

Rivers and Dry concluded that a patient who has gastric ulcer should be suspected of harboring malignancy if the symptoms are of short duration, if they have persisted without remission, if relief from a careful medical regimen

is inadequate, and if blood has continued to appear in the stool. They expressed the belief that there is still greater probability that the lesion is malignant if, in addition, the ulcer is large, if it is situated near the pylorus on the greater curvature or anterior wall, and if hydrochloric acid is demonstrably absent from the gastric content or if the concentration of the acid therein is low.

Doctors Rivers and Dry also stated that certain criteria may suggest that the lesion is of a benign nature. This probability is supported if the patient is young, if there are long periods during which the ulcer is quiescent, if gastric acidity is high, if bleeding from the lesion is intermittent, and if the ulcer exhibits characteristics of penetration or if hour glass deformity is present. Added evidence is introduced to support the suggestion that the lesion is benign if clinical improvement takes place under treatment, if bleeding ceases, and if roentgenographic signs are obtained that the lesion is disappearing.

Altogether too frequently, however, the application of these same criteria has misled the physician in his judgment, to the serious jeopardy of his patient's life. In some cases in which the lesion is malignant, a medical and dietary regimen will be followed by prompt and practically complete relief of symptoms. Meanwhile, the lesion is permitted to progress stealthily; it is for this reason that only those patients who can be kept under close observation should be permitted to adopt such a plan of treatment, for it is based on the assumption that the lesion is benign. A sense of false security has developed among physicians with regard to the benign aspect of certain gastric lesions for which they have advised non-surgical treatment. This may usually be attributed to the fact that certain criteria have been utilized in some instances to the advantage of the patient and that in some of the cases the disease has been cured.

One must also bear in mind that gastric and duodenal ulcers coexist in 13 per cent of cases. The discovery of a duodenal ulcer may seem to explain the symptoms and for this reason a gastric ulcer may be overlooked if investigation of the stomach is not carried out carefully, either by fluoroscopic examination or by inspection at the time of surgical operation.

Even under direct inspection it is often impossible to distinguish between malignant and benign lesions of the stomach, although the size of the lesion does seem to be of some assistance in making the differential diagnosis. According to a study of the ulcers resected at the clinic, four out of five benign ulcers are less than 1.8 cm. in diameter, while 92 out of 100 are less than 2.4 cm. in diameter. Furthermore, in numerous instances, multiple ulcerating lesions are found in the stomach, one of which is malignant. Attention may be focused on the lesions that are benign and healing, whereas the ulcer that is smallest of all may harbor within its periphery unmistakable evidence of malignancy. Occasionally benign ulcers attain considerable size. It has been interesting to observe that 23 per cent of the carcinomas resected at the clinic were within the range of size of benign ulcers. All signs fail in so many instances that it would seem to be extremely hazardous to venture positive opinions regarding the exact histopathology, especially of small ulcers.

In carrying out the treatment, resection should be performed if the lesion is so large that excision of a considerable portion of the wall of the stomach would be required to remove the ulcer and therefore an extensive plastic procedure would be necessary to reconstruct the stomach. If the lesion is malignant grossly, it is usually preferable to perform resection. I think that one of the reasons for the willingness to operate on patients with gastric ulcer, before it is possible to demonstrate the presence of malignancy, is that such excellent

results have followed the conservative procedure of excision and gastro-enterostomy. About 80 per cent of all gastric ulcers are small, and excision will be all that is required. The immediate risk of the procedure is less than that of other operations for gastric ulcer. Subsequent formation of jejunal ulcer is not a consideration in operations on the stomach, for jejunal ulcer can be said to be almost exclusively a complication of procedures undertaken for relief from duodenal ulcer. I have been so impressed with the results of excision and gastro-enterostomy for gastric ulcer that I feel I should call attention to the operation at this time. Reports from many hundreds of patients indicate that this conservative operation apparently will accomplish a more satisfactory function result, and will give a better end-result than will come from resection of the stomach.

I also agree with Doctor Scott's statement that too pessimistic an attitude should not be adopted even if the criteria suggest the presence of a rather extensive malignant process. One is unable to state with certainty that a very small ulcer is benign, but it is also quite as impossible to be sure that a large ulcer, having considerable induration about it, will prove to be malignant.

On account of the difficulty of distinguishing between benign and malignant gastric ulcer and the danger of permitting malignant transformation to progress if medical treatment is given a trial, I think that practically all patients with gastric ulcer should be given the advantages offered by surgical removal of the lesion.

DR. FRANK H. LAHEY (Boston, Mass.).—This is a very important subject to take up from time to time. I think we all have to take the position, as Doctor Scott has suggested, that every gastric ulcer should be considered malignant until proven otherwise. On the other hand, it would be quite wrong if we resumed the attitude which we had in the past that all gastric ulcers are to be surgical because of the danger of malignancy. I do believe that the percentage of malignancy is relatively low and I believe that if we were to resect all ulcers on this basis the mortality of resection would more than parallel the mortality of malignant degeneration in ulcer.

We have proven to our satisfaction that there is no ulcer, when it is a tractable ulcer, which heals as satisfactorily under medical treatment as does gastric ulcer.

It is interesting to see these defects in the lesser curvature at the operating table. They are usually distortions. When you look at the ulcer with the abdomen open you do not find alcoves which correspond to the roentgenogram. They are, I think, retractions due to exudate in the gastrohepatic omentum and about the ulcer, and the rapid disappearance of this alcove defect in ten days to three weeks, is, I think, secondary to disappearance of this exudate.

Doctor Jordan in our Clinic has practiced, and I have preached throughout this country now for a number of years, this very attitude of which Doctor Scott speaks, and that is the test of malignancy by a trial of medical treatment. There is no such thing as an exploration of a chronic gastric ulcer. If you get that far and open the abdomen you resect it if you are in doubt, and if it is a frank cancer you are not in doubt.

The thing we have wanted always is preoperative help as to operative decision, because I would feel most depressed to do a subtotal gastrectomy on an untreated ulcer, have it prove to be a simple ulcer, and have the patient die. I would always feel that that patient might well have been handled under medical direction and so I have desired some preoperative indication which would justify the risk of subtotal gastrectomy.

We have preached and practiced these criteria, and I think they are de-

pendable—if, under two or three weeks of medical regimen, patients fulfill the following criteria, they may be safely continued under medical measures: (1) Complete disappearance of symptoms. (2) Complete disappearance of blood in the stools. (3) Most important, not only disappearance of the defect under the fluoroscope, but peristaltic waves must pass flexibly through the area where the ulcer existed.

If, in addition to that, there may be a return of the ulcer, surgery is immediately indicated; if there be hemorrhage, surgery is immediately indicated, and if one attacks the ulcer under these conditions, no matter what the outcome as to mortality, it is justifiable because the lesion is then either malignant or an intractable ulcer, and in either event, subtotal gastrectomy is justifiable.

I believe this plan (and it makes no difference whose it is, we are only interested in whether or not it is worth while) is a very valuable and comforting one to the surgeon. I do believe that patients under this trial of treatment should be in bed. If one has to make a decision for or against operation on the basis of this trial of medical treatment, then it cannot be too painstaking. It cannot be too accurate and if it is to be done, it should be explained to the patient so that he or she understands the need of complete rest in bed and an accurate regimen upon which to make the decision.

This plan has been of great help to me and has saved me numerous heartaches which I had before we employed it. I think this is an extremely valuable contribution in that it again impresses the need of a trial of preoperative medical management on all surgeons' minds.

DR. ROSCOE R. GRAHAM (Toronto, Ont.).—We too have followed the type of management preoperatively which Doctor Scott has outlined, and which has been suggested by Doctor Jordan of the Lahey Clinic.

We can most heartily endorse the soundness of this regimen. We have noted, however, that complete disappearance of all radiologic evidence of ulcer can occur, even showing peristaltic waves passing across the ulcer area during the fluoroscopic examination, and yet subsequent examination has proven such an ulcer to show malignancy. We place a certain reliance on the site of the ulcer. In an analysis of cases in which we took the incisura as the midpoint, we found that 94 per cent of the ulcers situated between the incisura and the pyloric vein were histologically malignant, while of those occurring from the esophagus to the incisura, only 40 per cent were malignant, and of the 60 per cent which were benign, 35 per cent had an associated hour glass contraction of the stomach. We also have had no patient past 60 years of age who had suffered from a simple gastric ulcer and in whom the symptoms of indigestion occurred after that age. Therefore in this group of patients we believe operation is indicated, but prior to operation all are submitted to bed rest with an indwelling duodenal tube. Even with such a regimen, if the ulcer should show a very material decrease in size, and be situated between the angularis and the pyloric vein, we still advise operation. We are very much impressed with the value of bed rest and an indwelling duodenal tube, even in malignant ulcers, as there is, as a result of this therapy, a marked diminution in the per-ulcer inflammation and edema, thus lessening the likelihood of postoperative infection of the suture line.

The presence or absence of free hydrochloric acid is not of great significance in differentiating between benign and malignant ulcer, except that we very rarely see a malignant ulcer with a very high free hydrochloric acid content in the gastric analysis. The absence of free hydrochloric acid in gastric analysis is fairly common. We have recently carried out a series of gastric

analyses of patients admitted routinely for any cause, and found an absence of free hydrochloric acid in 50 per cent of the patients over 50 years of age.

DR. W. J. MERLE SCOTT (Rochester, N. Y.).—The seriousness of this problem is that carcinoma of the stomach is the most common cause of death from carcinoma. Twenty-five per cent of those carcinomas of the stomach appear clinically first as ulcer or mimic ulcer. The percentage of cases that exactly mimic ulcer, that you think after careful study of all clinical manifestations are probably benign ulcers, will perhaps not be that high.

But we should get across to practicing physicians and surgeons the fact that patients with lesions of the stomach that seem to be ulcers have a high incidence of carcinoma, and develop over a period of time a method of satisfactorily picking out certain lesions that should be operated on at once as carcinoma because of its high incidence such as that class which Doctor Graham called attention to in the prepyloric region—Dr. Holmes several years ago showed that the prepyloric ulcer was over 90 per cent malignant even though it was a very small ulcer.

If we call attention to these possibilities of handling the cases, separating out the majority of them that will respond to medical treatment within a short period of time, and yet submitting the others to whatever type of operation is carried out for carcinoma, I think we will have made a step forward in increasing the percentage incidence of cure of carcinoma of the stomach.

I certainly have no quarrel with Doctor Judd and I am sure he agrees with me. The only thing I wish to emphasize is that we should treat these cases, where they fail to respond to medical treatment, just as if one had the section of the lesion under the microscope. This proves to be carcinoma in a great many cases where one selects the case in that way. There will be a few of these ulcers that are adherent to the liver and pancreas, or have other complications that account for their failure to respond.

ACUTE ILEUS

COMPARISON OF TOXICITY OF OBSTRUCTED AND NON-OBSTRUCTED INTESTINAL CONTENTS

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PART I: QUALITATIVE

ACCEPTING the dictum that a poison was present in the obstructed intestine which could not be found in the unobstructed intestine, the experiments, the results of which are here reported, were begun in 1926. Their object was to ascertain whether or not, if such a poison did exist, there was any demonstrable time factor in its formation: in other words, whether the obstructed gut contents became more toxic the longer the obstruction lasted and, if so, how soon after obstruction they first began to be demonstrably toxic as tested by intravenous injection into other animals. If the results were positive, it was hoped that any definite time factor discovered might be used as a basis for rational recommendation regarding the possible use of enterostomy in human cases of acute ileus. A preliminary report¹ was published in 1927.

The published results of various investigators ^{2, 3, 4, 5, 6, 7, 8, 9}, up to that time were therein summarized as follows: "In obstructed intestines, the time factor for the formation of poison sufficient to cause marked sickness or death of the animal into which the content was injected (intravenously or intraperitoneally) has been found by different workers to vary from four hours to ten days." These variations noted appeared to depend partly upon (a) the level of obstruction; (b) the type of obstruction, whether simple or by closed loop; (c) whether there was or was not any serious trauma to the intestinal or mesenteric blood supply; (d) the preparation of the content for injection; (e) the amount used for injection; (f) the variety of the animal used in the experiment; and (g) individual differences of reaction in animals of the same kind.

The experiments herewith reported were undertaken specifically to determine whether any more definite information than this could be obtained in relation to the length of time required for the formation of poison. In order to avoid some of the presumable causes of variation in results (noted above) the following limitations were imposed:

(a) The intestine was obstructed at the same level in all cases (about 30 cm. from the duodenojejunal junction). This point of obstruction was used in all cases except the 12 hour group in which a point a little higher was selected by mistake.

(b) The technic of obstruction was as nearly as possible the same in every case.

(c) Similar care was used in every case to avoid injury to the mesenteric vessels.

(d) The animals were killed by anesthetic in the same way at the end of the fixed period for each hour group, and were autopsied immediately. The mucosa and intestinal contents were removed in the same way in every case (immediately upon death of animal) into a fixed amount (200 cc.) of boiling water and sterilized by boiling for approximately five minutes. The material thus secured was extracted and prepared for injection by the same technic in every case.

(e) The amount injected was in each case the residue extracted from the entire content and mucosa of the obstructed segment of one dog up to the pylorus. This extract concentrated in water varied from 10 to 18 cc. in bulk.

(f) The same variety of animal (dog) was used in every case.

There remained at least four variables that were not controlled by these standards:

- (1) The actual amount of poison injected was unknown.
- (2) The animals used for injection test were not all of equal weight.
- (3) The animals injected differed somewhat in apparent physical condition.
- (4) No constant could be assumed as to their individual reactability to the poison.

These variables are exceedingly important, for Ingvaldsen, A. O. Whipple, Bauman and Smith¹⁰ showed that the dried extract of the ileus toxin was lethal to dogs injected intravenously in the amount of about 13 mg. to the kilo of body weight. The first two of the above variables could have been controlled but the last two could not. However, these variables (in addition to others) necessarily exist among cases of acute ileus in humans with which it was expected to compare the results of this experimental animal study. For this reason, in addition to the difficulty of procuring animals of exactly the same weight and because the technical process of securing the toxin in a dry refined state is long and difficult, these two controllable variables were left uncontrolled.

Method: Typical Experiment.—Through a median abdominal incision and with careful aseptic technic a presumably healthy dog under ether anesthesia had the jejunum tied off tightly by one-half inch cotton tape 30 cm. below level of duodenojejunal junction, except in the 12 hour obstruction group where (by mistake) the gut was ligated 30 cm. below pylorus, leaving a much shorter obstructed segment, care being taken not to injure the mesenteric vessels. The abdominal wound was closed, dressing applied and the animal returned to his cage. Water ad lib (but no food) was given after operation till death. The obstructed dog was killed by chloroform anesthesia

at the end of a predetermined interval after obstruction.* The abdomen was immediately opened and the intestine from pylorus to obstructed point 30 cm. below duodenojejunal junction removed. The content of this portion was squeezed into a beaker containing about 200 cc. of boiling water. The resected intestine was then split longitudinally, the mucosa was scraped off from the muscularis by the handle or back of a scalpel and transferred to the boiling water with the intestinal contents. Boiling was continued about five minutes and the contents of the beaker then transferred to a mason jar and removed to the Chemical Laboratory. The chemical treatment was that followed by Ingvaldsen, Whipple, Bauman and Smith.¹⁰ The mixture was filtered through gauze and cotton and treated with five volumes of 95 per cent alcohol. The precipitate, dissolved in water, was boiled with 1 Gm. of magnesium sulfate, then filtered through paper and re-precipitated with five volumes of alcohol. The precipitate was dissolved in a small amount of water and dialyzed in a collodion sac against distilled water for five days with thymol used as a preservative. The neutral mixture, now free from magnesium sulphate, was centrifuged and the supernatant fluid removed, boiled with acetic acid for a few minutes, cooled and again centrifuged. The clear fluid again precipitated with alcohol was filtered and the precipitate dissolved in a small amount of water. The extract of the obstructed intestinal content and mucosa thus obtained† was sterilized by boiling and each specimen was tested as follows:

Under ether anesthesia in a presumably healthy dog, a small incision was made in left side of neck exposing left external jugular vein. Anterior wall of vein was picked up between fine toothed forceps and hypodermic needle introduced. The filtered, refined, sterilized intestinal extract (varying in bulk from 11 to 18 cc.) was slowly injected. The needle puncture was then closed by ligature, the wound in neck closed by suture and animal returned to cage for observation. They were observed at about hourly intervals for the first five or six hours following injection and after that not observed again till about 24 hours after injection. All dogs that died showed symptoms of severe toxemia, apparent discomfort, marked prostration, vomiting and purging which was frequently of blood tinged material, slow respirations, weak hind extremities. Every injected dog that died was autopsied as soon after death as practicable. There was found at autopsy in all cases the typical congestion of intestinal mucosa often accompanied with mucosal hemorrhages, and bloody intestinal con-

* There were 5 hour-groups, of five or six dogs in each, as follows: Five 72 hour obstruction; five 48 hour obstruction; six 36 hour obstruction; six 24 hour obstruction (2 groups); six 12 hour obstruction.

† The amount varied between 11 cc. and 18 cc. in different instances. The color varied from watery opalescent to greenish or brownish and in some cases there was a small sediment at the bottom of the test tube. Experience showed that the color and sediment did not appear to indicate in any way the relative toxicity of the fluid.

tents which is apparently a characteristic effect of obstructed intestinal content poisoning.

The results of the tests may be tabulated as follows:

GROUP A

Adult Dogs — 72-Hour Obstruction

Serial No. obstructed dog	Serial No. injected dog	Amount of fluid injected	Results
8240	8315	10 cc.	Slight toxemia. Recovery complete in 24 hrs.
8352	8413	15 cc.	Severe toxemia. Recovery after 24 hrs.
8269	8414	15 cc.	Very severe toxemia. Dead in 2¾ hrs.
8326	8415	18 cc.	Severe toxemia. Recovery after 24 hrs.
8358	8416	17 cc.	Severe toxemia. Dead in 6 to 24 hrs.

GROUP B

Adult Dogs — 48-Hour Obstruction

8386	8547	10 cc.	Severe toxemia. Recovery after 48 hrs.
8359	8548	17 cc.	Severe toxemia. Recovery after 48 hrs.
8487	8549	14 cc.	Severe toxemia. Recovery after 48 hrs.
8447	8550	16 cc.	Severe toxemia. Dead in 5 hrs.
8430	8551	16 cc.	Severe toxemia. Dead in 6 to 19 hrs.

GROUP C

Adult Dogs — 36-Hour Obstruction

8704	8773	14 cc.	Severe toxemia. Recovery after 24 hrs.
8714	8774	13 cc.	Severe toxemia. Dead in 10 to 23 hrs.
8717	8775	15 cc.	Moderate toxemia. Recovery after 24 hrs.
8723	8776	15 cc.	Moderate toxemia. Recovery in 24 hrs.
8730	8777	14 cc.	Slight toxemia. Recovery in 24 hrs.
8735	8778	16 cc.	Severe toxemia. Dead in 4½ hrs.

GROUP D

Young Puppies — 24-Hour Obstruction

8826	8858	7 cc.	Moderate toxemia. Recovery within 24 hrs.
8827	8859	6 cc.	Severe toxemia. Dead within 2½ hrs.
8828	8860	6 cc.	Severe toxemia. Dead within 3½ hrs.
8829	8861	8 cc.	Severe toxemia. Dead within 3¼ hrs.
8830	8862	6 cc.	Severe toxemia. Dead within 3 hrs.
8831	8863	7 cc.	Severe toxemia. Dead within 3½ hrs.

Following our original hypothesis, it had been expected that the 24 hour obstruction contents would show less toxic power than that of the 36 hour, 48 hour and 72 hour groups. For that reason puppies, instead

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of adult dogs, were chosen as they were believed to be more susceptible, just as children are apparently more susceptible to intestinal disturbances than are adults: the injection of the intestinal content into a vein being held to represent a situation similar to its rapid absorption from the intestinal mucosa via its lymphatics and veins. The 24 hour obstruction poison when tested in puppies was, however, apparently so much more deadly than the longer obstruction poison that we were led to question the validity of the results as a fair comparison with the other hour groups. The test was, therefore, repeated, every factor being similar except that adult dogs were used for the injection as in the other hour groups. The results are tabulated below.

GROUP E

Adult Dogs — 24-Hour Obstruction

Serial No. obstructed dog	Serial No. injected dog	Amount of fluid injected	Results
9355	9397	10 cc.	Very slight toxemia. Rapid recovery.
9356	9398	12 cc.	Very slight toxemia. Rapid recovery.
9357	9399	12 cc.	Moderate toxemia. Found dead after 24 hrs. Pneumonia.
9358	9400	10 cc.	Very slight toxemia. Rapid recovery.
9359	9401	11 cc.	Slight toxemia. Rapid recovery.
9360	9402	10 cc.	Very slight toxemia. Rapid recovery.

The results in this second group of 24 hour obstruction were so different from the results in the first 24 hour group that we decided to try a 12 hour obstruction group. The results of this experiment are tabulated below.

GROUP F

Adult Dogs — 12-Hour Obstruction

Serial No. obstructed dog	Serial No. injected dog	Amount of fluid injected	Results
9095	9154	12 cc.	Very slight toxemia. Rapid recovery.
9096	9155	10 cc.	Severe toxemia. Dead in 5 to 8 hrs.
9097	9156	12 cc.	Very slight toxemia. Rapid recovery.
9098	9157	11 cc.	Very slight toxemia. Rapid recovery.
9099	9158	11 cc.	Very slight toxemia. Rapid recovery.
9100	9159	10 cc.	Very slight toxemia. Rapid recovery.

The fact that there were deaths in the early obstruction as well as in the late obstruction groups led us to question whether we had been justified in our original assumption that there was a poison in the obstructed intestine which could not be demonstrated in the non-obstructed intestine. We therefore decided to test by injection the toxicity of material from non-obstructed intestines obtained, refined, and injected in exactly the same way as the content of obstructed intestines had been. The results are tabulated below.

GROUP G

Adult Dogs — Non-Obstructed Control

Serial No. non-obstructed dog	Serial No. injected dog	Amount of fluid injected	Results
9657	9775	about 10 cc.	Severe toxemia. Dead in 4 hrs.
9653	9776	13 cc.	Apparently recovering from toxemia after 4 hrs. but found dead 24 hrs. later.
9656	9777	11 cc.	Severe toxemia. Dead in 3 hrs.
9652	9778	11 cc.	No toxemia, apparently.
9655	9779	12 cc.	Very slight toxemia. Rapid recovery.

The death of three out of five dogs in this GROUP G (following injection of the extract of non-obstructed intestine) made it appear that there was actually present in the non-obstructed intestine a poison similar to that found in the obstructed intestine. Moreover, at autopsy, two out of the three dead dogs had the bright red congestion of the small intestine mucosa (most marked in the duodenum and fading toward the ileum) together with blood-tinged contents that we have previously associated only with the fatal toxemia following injection of obstructed intestinal contents. Findings in the third dead dog were suggestive but not convincing of the same pathology. It, therefore, seemed impossible to retain our original assumption that there was no similar poison in the non-obstructed intestine. This conclusion appears more inevitable if we summarize the results which have been tabulated above for the individual groups and contrast them with each other. A summary of the results (tabulated in individual groups above) is shown below.

*Summary of Results of Toxicity Tests of Various
Obstructed and Non-Obstructed Contents*

Group	No. of dogs	No. died	Mortality per cent of group	Remarks
72-hr. obstruction	5	2	40	All adult dogs.
48-hr. obstruction	5	2	40	All adult dogs.
36-hr. obstruction	6	2	33½	All adult dogs.
24-hr. obstruction	6	5	83½	All young puppies. May have extra susceptibility.
24-hr. obstruction	6	1	16½	All adult dogs.
12-hr. obstruction	6	1	16½	All adult dogs.
Non-obstructed	5	3	60	All adult dogs.

This summary shows two striking features: the high mortality of the group of puppies injected with 24 hour obstruction fluid and the high mortality of dogs injected with non-obstructed intestine contents. Ignoring these two groups for the moment the above summary seems to indicate an increase in the toxicity of the obstructed contents with the longer periods of obstruction. But the two striking groups cannot be ignored. They must either be satisfactorily explained or it must be admitted that the original

assumption (poison present in obstructed contents but not in normal contents) is invalid and that the object of the experiments (to ascertain at what period—after onset of obstruction—poison becomes demonstrably present in the intestine) was unattainable.

If we had not used the puppies among the test animals and if we had not tested the toxicity of the non-obstructed contents, our results would have been apparently satisfactory, logically to be expected and rather convincing. But they would have been fallacious.

SUMMARY OF PART I

The results of this first group of experiments (designed to discover whether or not the contents of the obstructed intestine became demonstrably more toxic with the increase in the obstruction time) were inconclusive: first, because the test of the 24 hour material, on puppies, made it appear more toxic than the 36 hour, the 48 hour or the 72 hour material; and secondly, because the non-obstructed material appeared to be more toxic than the obstructed material.

It might be plausibly argued that the puppies tested were more susceptible than adult dogs and that, because of their small size, they received relatively larger dosage of the material than did the adult dogs. This argument could be supported by the fact that, when adult dogs were tested with similar (24 hour) material, they appeared to be—on a mortality percentage basis—five times more resistant than the puppies.

As regards the non-obstructed control tests, it might be argued that some of the apparently normal dogs, from which the non-obstructed intestines were taken, really had distemper with no other sign of it than the slightly congested mucosa which was noticed in two or three of them. The non-obstructed intestinal contents of dogs suffering from distemper have been shown by Ellis²⁰ to be decidedly toxic. All we can say, in this regard, is that—if they had distemper—the signs were too obscure for us to recognize and we considered these dogs to be healthy.

If now we should ignore the result of the test on the group of puppies (which would seem almost justifiable) and in the non-obstructed control group (which would not seem justifiable) it would appear that the first group of experiments indicated an increasing toxicity with the increase in length of obstruction time (based on an increasing percentage of mortality in the injection tests).

We do not, however, believe that this appearance is reliable. It seems rather to be fallacious, particularly when viewed in the light of the results of the second group of experiments (whose report follows) which were designed to compare quantitatively the relative toxicity of obstructed and non-obstructed contents. But even in the light of these qualitative tests, we believe the non-obstructed contents to be toxic.

PART II: QUANTITATIVE

On the assumption that there was poison present in non-obstructed intestine, the question arose as to whether it existed in amounts at all similar to those found in the obstructed intestine.

Ingvaldsen, A. O. Whipple, Bauman, and Smith,¹⁰ in 1923, secured 1 Gm. of dry toxic substance from the obstructed intestine of 14 dogs, using a method of chemical extraction similar to that described by Ellis but with additional steps to further purification. Seventy-one mg. of this toxic substance dissolved in water and injected intravenously into a dog weighing 5½ kilos (13 mg. to the kilo) resulted in a characteristic toxemia and in his death in 2¾ hours. Autopsy showed the characteristic intestinal pathology of intense mucosal irritation.

In 1928, we killed by chloroform five presumably healthy dogs and removed into boiling water the contents and mucosa of nearly the entire small intestines. Through the kindness of Dr. Edgar G. Miller, this was treated in the Department of Biochemistry by exactly the same method of extraction and purification which Ingvaldsen and collaborators had reported in the case of obstructed contents. The dry substance thus secured weighed 186 mg. It was of dirty white color, chalky consistency and when dissolved in water made a cloudy, opalescent solution. Two apparently healthy dogs were selected and the toxin, dissolved in water and freshly sterilized by boiling, was slowly injected into the external jugular vein exactly as in the previous experiments. The results are tabulated below.

GROUP H

Adult Dogs — Non-Obstructed Controls

Serial No. injected dog	Weight of dog	Weight of dried extract in cc. water	No. of mg. per kilo	Results
9972	5.9 Kg.	75 mg. in 7.5 cc. water	12.7	Vomiting and purging and marked depression. Moribund in 8 hrs. Found dead next day. Pneumonia.
9973	6.1 Kg.	90 mg. in 9 cc. water	14.7	No vomiting or purging. Moderate depression. Almost completely recovered at end of 8 hrs.

There are two interesting points of contrast here indicated between the contents and mucosa of obstructed and non-obstructed intestine: (1) The amount of dried extract obtainable (using the same chemical method); and (2) its effect when injected intravenously.

From the obstructed intestine of 14 dogs was obtained 1,000 mg. of dried extract, an average of 71 mg. per animal. From the non-obstructed intestine of five dogs was obtained 186 mg. of dried extract, an average of 37 mg. per animal. When injected intravenously (in approximately the same amount of mg. per kilo of body weight) the obstructed extract killed a dog in 2¾ hours with autopsy findings typical of acute ileus poisoning. The non-

obstructed extract had very slight apparently toxic effect on one dog and, when tested on another, showed only moderate effect within four hours and, although this latter dog was found dead the next day there were no characteristic pathologic findings as in acute ileus poisoning and there was an early pneumonia of one lung which probably contributed to its death. These observations were so much at variance with those in GROUP G, where the less refined non-obstructed contents accounted for a 60 per cent mortality of injected dogs, that it seemed worthwhile to persist in the attempt to compare quantitatively the toxic effect of obstructed and non-obstructed contents.

In 1935, therefore, a group of 13 non-obstructed, apparently relatively normal dogs were killed by chloroform, the small intestinal contents and mucosa from pylorus to cecum were removed and treated by the same method used in 1924 by Ingvaldsen, A. O. Whipple, Bauman and Smith.¹⁰ The chemical work was done in the chemical laboratory of the Department of Surgery at the College of Physicians and Surgeons by Miss Hamlin under the direction of Dr. Louis Bauman. Nine hundred and twenty mg. of dry residue was secured by this method from 13 non-obstructed dogs as compared with 1,000 mg. obtained from 14 obstructed dogs in 1924. This dried residue was dissolved in 92 cc. of 0.9 per cent sterile Na Cl solution (10 mg. to 1 cc. of solution) and, being found slightly acid, was neutralized to phenolphthalein by adding a little sodium carbonate. The resulting solution was without precipitate, almost water-clear and colorless. The toxicity of the material was tested by injection into the external jugular vein of presumably healthy adult dogs, exactly as in the earlier experiments. The following table shows the amount injected and the results observed.

GROUP J

Adult Dogs — Non-Obstructed Controls

Serial No. injected dog	Weight of dog	Weight of dry extract	No. of mg. per kilo	Results observed
12825	14.7 Kg.	147 mg.	10.0	No sign of toxemia except slight depression.
12829	4.9 Kg.	70 mg.	14.3	Severe toxemia. Vomiting and purging. Recovered in about 6 hrs.
12826	14.0 Kg.	210 mg.	15.0	Moderate toxemia. Purging and depression. Recovery after 6 hrs.
12827	13.1 Kg.	209 mg.	16.0	Vomiting, purging, coma. Death in 2½ hrs. Characteristic autopsy findings.
12828	12.7 Kg.	216 mg.	17.0	Severe toxemia. Vomiting. Bloody stools. Recovery after 24 hrs.

Reviewing the results, it seems impossible to deny that this material, obtained from the non-obstructed intestines of apparently healthy dogs, is toxic. Bearing in mind the fact that it was obtained by exactly the same method of

chemical extraction which had been used by Invaldsen, Whipple, Bauman and Smith, in the obstructed intestine; added to the fact that, when injected into dogs, in the same way and in about the same amount as the obstruction poison, it gave rise to similar symptoms, one is inclined to believe that its toxicity may be due to similar (if not the same) factors as in obstruction poison. It is possible, of course, that the poison may be the same as obstruction poison, but we have no evidence to justify such an assumption, because we made no chemical analysis of the non-obstructed extract.

One does not know whether the poison extract resides originally in the intestinal contents or in the mucosa. In the case of these non-obstructed dogs, it would appear to be in the mucosa. For the total contents recovered from the non-obstructed intestines of 13 dogs was only about 20 cc. of fluid and the usual worms. There was, however, roughly about three times as much mucosa taken by us from the non-obstructed intestines as was taken by Ingvaldsen, Whipple, Bauman and Smith from the obstructed intestines for chemical extraction. The entire small intestine was used in the former case, and only the obstructed segment in the latter. The contents of the obstructed intestines was, however, far greater than that of the non-obstructed intestine.

In both instances (obstructed and non-obstructed) approximately the same amount of extract was secured, in a dried to constant weight form. An average of 71.4 mg. was recovered from each of the obstructed dogs and an average of 70.8 mg. from each of the non-obstructed. Taking into consideration the fact that there was more contents and less mucosa in the obstructed dogs, it seems possible that the poisonous extract may have resided largely in the contents. In the case of the non-obstructed dogs, however, there was so great a preponderance of mucosa over contents that it seems probable the mucosa was largely the source of the extract.

Collecting the results, both qualitative and quantitative, of the toxicity tests and dividing them into two groups, Obstruction Extract and Non-Obstruction Extract, we may tabulate them as follows:

<i>Comparative Toxicity</i>			
<i>Obstruction Extract</i>		<i>Non-Obstruction Extract</i>	
No. of specs. tested.....	34	No. of specs. tested.....	12
No. producing symptoms.....	34	No. producing symptoms.....	11
No. resulting in death.....	13	No. resulting in death.....	5
Confirmed by autopsy.....	13	Confirmed by autopsy.....	4
Mortality rate 38.2%		Mortality rate 41.7%	

SUMMARY OF PART II

The second group of experiments (designed to test the toxicity of non-obstructed intestinal contents and mucosa and to compare the amount of poison and its degree of toxicity with that found in the obstructed intestine) were more convincing in their results. From them it appeared:

(1) That there is a toxic substance in the non-obstructed intestine whose action, when tested by injection, is similar to that of the so called obstruction poison.

(2) That, when quantitatively tested, it appears to be about as toxic as the obstruction poison.

(3) That (judging by the amount of mucosa used for the extraction and the amount of extract secured; in the obstructed and non-obstructed groups) the poison exists in smaller amounts in the non-obstructed than in the obstructed intestine. If these appearances are accepted as valid representation of the facts (and we are inclined to accept them as such) they argue against the commonly held conception of obstruction toxemia: that is as being due to a peculiar obstruction poison formed only after the onset of obstruction. They tend to suggest rather the prior existence of a poison in the non-obstructed intestine which, after the onset of obstruction, is collected there in larger amounts, due to the lowered absorption from an obstructed intestine, and to the impossibility of discharging it through the normal channel. They tend similarly to strengthen the claims of those who argue that the normal uninjured mucosa does not allow to pass into the lymphatics and blood vessels poisons which are apparently able to pass through the mucosa after it has been injured sufficiently to interfere with its integrity as a protective agent.

DISCUSSION

From these collected observations, therefore, one gets the impression that there is little difference, qualitatively and quantitatively, between the toxicity (intravenously injected) of the extract from obstructed and non-obstructed intestinal contents in dogs. The observations reported herein are, however, too few to carry much weight by themselves and confirmatory evidence must be sought to reinforce the impression that they give. Such confirmation may be found in the reports of work done by Kukula,⁶ Charrin,¹² Bouchard,¹¹ Magnus-Alsleben,¹³ Roger and Garnier,¹⁴ Falloise,¹⁵ Cybulski and Tarchanoff,¹⁶ Braun and Boruttau,¹⁷ Davis, D. M.,¹⁸ Wangenstein and Chunn.¹⁹

Bouchard, in 1887, tested the watery (also alcohol and ether) extracts of non-obstructed intestines by injection into animals and reported them to be toxic.

Kukula, in 1901, investigating normal intestinal contents, found toxic substances and classed them as (a) breakdown products of carbohydrates and (b) putrefaction products of proteins.

Charrin, in 1904, stated that, in its non-obstructed condition the intestinal contents are poisonous.

Magnus-Alsleben, in 1904-1905, said that a toxic substance existed in non-obstructed, upper small intestine contents and mucosa after feeding various kinds of meat and apparently also after bread, fats and starches.

Roger and Garnier, in 1905-1908, tested by injection the toxicity of gastric, small intestine and colon contents of non-obstructed intestine. They

used dogs and rabbits and reported that the contents of the small intestine were more toxic than gastric or colon contents. Their conclusion regarding the non-obstructed contents was that it was remarkable for the constancy of its toxicity and for the consistency of its toxic dosage. Then, comparing the toxic dosage of obstructed small intestine content with that of the non-obstructed, they reported that the latter was rather more poisonous than the former. They precipitated the obstructed contents with alcohol and found the precipitate (dissolved and injected in water) very fatal while the filtrate was only mildly toxic. Their final conclusion regarding the relative toxicity of obstructed and non-obstructed contents was that occlusion of the intestine (obstruction) in dogs lessens the toxicity of its contents below that of normal contents.

Fallose, in 1907, made a careful study of the various products of digestion found in the intestine of the human and of certain animals. He stated that the normal contents of human intestine was toxic for dogs and rabbits (as tested by injection into vein) and that normal contents of these animals were also toxic for the same animals. He studied only the non-obstructed contents believing that the obstructed contents were abnormally conditioned. He sterilized the watery extract of intestinal contents by tyndallization (repeated to 55° C.) and his experimental work was carefully planned and executed. His deductions were thoughtfully made and are highly convincing. He recorded accurately the symptoms produced by the injections. The most striking and consistent symptoms were (1) rapid fall of blood pressure, (2) severe dyspnea, (3) incoagulability of the blood, and (4) hypoleukocytosis. He said that the severity of the symptoms and their rapidity of onset appeared to depend upon (a) the amount injected, (b) the speed of injection, and (c) the individual resistance of the dog tested. His final conclusion was that normal, non-obstructed contents were toxic and that the toxicity probably came from products of digestion in the small intestine as the contents of this were more poisonous than those of large intestines.

Cybulski and Tarchanoff, in 1907, repeated enough of Fallose's experiments to confirm his results. But they differed from his deduction that the toxicity of normal intestinal contents was due to digestive products. They claimed that the toxicity was due to the digestive ferments and particularly to the pancreatic juice.

Their final conclusion was that normal intestine contents were toxic but that the toxicity was due largely to the presence of pancreatic juice; because, by injecting the latter alone, they secured results almost entirely similar to those of Fallose's injections with small intestine contents.

Brown and Boruttau, in 1908, after numerous obstruction experiments on dogs and cats, undertook a similar research on apes. They called attention, in their report, to the fact that several previous investigations had claimed that obstructed contents were more toxic than normal contents. Brown and Borut-

tau, however, felt that the methods used had not been sufficiently exact to make such claims convincing.

They themselves had found that, in certain injection experiments, using equal amounts of obstructed and of non-obstructed contents, the latter was sometimes lethal and the former was not. They did not, apparently, as Roger and Garnier had, test quantitatively with any exactness the relative toxicity of obstructed and non-obstructed contents. However, they secured the strong impression that obstructed contents may be no more toxic than normal contents. They found that absorption from the intestine was slowed down by obstruction conditions. In general, they agreed with the work of Roger and Garnier and of Falloise. Finally, they concluded that there was no demonstrable proof of a special obstruction poison and that the normal intestinal contents were rather more toxic than the obstructed contents. Moreover, they held that absorption from an obstructed intestine was so greatly slowed down that in some cases the presence of a lethal dose of strychnine in the obstructed gut failed to cause strychnine poisoning.

Davis, in 1914 found the normal intestinal contents of dogs, containing the ordinary food residues, fatally toxic when injected intravenously into other dogs. He also made fistulae in dogs 35 cm. below the pylorus and tied off or dissected away the pancreatic and bile duct so that no bile or pancreatic juice could enter the gut. Fluid syphoned from these fistulae, when injected intravenously into other dogs, had, in all cases, effects identical with those caused by injection of closed loop fluid. He accepted this as evidence that normal small intestine secretion without the presence of bile or pancreatic juice was quite definitely toxic.

Wangensteen and Chunn, in 1928, compared the toxicity of obstructed and normal intestinal contents, using dogs. They used contents only, apparently, and no mucosa. The normal contents were expressed (after killing the animal) from the whole of the small intestine. The contents of obstructed dogs (after two or three days obstruction) were expressed separately from above and from below the point of obstruction and tested separately. The contents were filtered (under suction) until clear, often colorless and sterile. The amount injected was usually about 15 cc. The normal contents were injected into seven dogs with mortality of 28.6 per cent. The obstructed contents were injected into ten dogs with no mortality. They then tested on rats the normal and obstructed contents of dogs. The normal contents (injected intraperitoneally) gave a 7.7 per cent mortality; the obstructed contents (from above the obstruction) gave a 9.9 per cent mortality and the contents from below the obstruction gave a 75 per cent mortality. Normal contents of rabbits' intestine injected into rats (intra-peritoneally) gave 33.3 per cent mortality and obstructed contents gave a 20 per cent mortality.

Their conclusions were that all intestinal contents were toxic on injection; furthermore, that the contents of non-obstructed dog or rabbit when injected

gave rise to the same symptoms as obstructed contents and were just as toxic.

Taking these reports collectively, we have here a considerable weight of evidence in favor of a definite poison or poisons existing in the contents and mucosa of the normal, non-obstructed small intestine: a poison which when injected intravenously gives rise to symptoms similar to those caused by the injection of obstructed contents.

If this evidence be accepted as valid it would seem hardly profitable to look any longer for a specific obstruction poison; an acute ileus toxin. For, if similar poisons are present in the intestine before and after obstruction, the vital question is not how and why they are formed but rather how and why they are absorbed, in lethal dosage, after obstruction and not before.

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CIRCULATORY DISTURBANCES CAUSED BY INTESTINAL OBSTRUCTION

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INTESTINAL obstruction may disturb the circulation of the bowel wall, the intra-abdominal circulation as a whole, and the systemic circulation. The causes, effects, and interrelations of these disturbances make up the subject matter of this paper. For the literature up to 1911 we have relied chiefly on the article by Enderlen and Hotz.¹ The Library of the Surgeon General has over 5,000 references on intestinal obstruction. The existence of this vast literature is sufficient proof that knowledge of the subject is imperfect. The bodily derangements caused by intestinal obstruction are too complex and widespread to permit of simple explanation. Since the circulatory phenomena of ileus are of constant occurrence and primary importance, it has seemed to use that the accumulation of exact information about them is a prerequisite to progress in the study of the disease.

We report our results and conclusions to date. In the course of this work we have encountered many problems which still demand solution. It is our impression that the conditions involved in many recorded experiments on bowel obstruction have been so complicated that clear cut conclusions cannot be drawn from their results. To avoid this error we have tried to use simple experiments which give definite answers to single questions, and to draw no general conclusions which these answers do not justify.

Disturbances of the Circulation Through the Bowel Wall.—The most important causes of impaired circulation in an obstructed bowel are distention and interference with the flow of blood in its mesentery. Increased peristalsis, disturbed vasomotor action, increased intra-abdominal pressure, and impairment of the systemic circulation are additional causes which should be considered. Kader² was the first to make a scientific study of the effects on the bowels of venous congestion and distention. He underestimated the effects of distention. This was because his experiments were done on the dog, whose intestine has a powerful muscular coat, which is able to empty accumulations of gas and fluid above an obstruction into the stomach, whence they are expelled by vomiting. The dog's intestine is thus protected against distention. The rabbit has a thin intestine and cannot vomit. Its intestine is readily injured by distention. The effect of distention upon the human intestine is probably about intermediate between these extremes.

Kocher³ was probably the first to call attention to the injurious effects of distention alone upon the bowel. His observations were clinical. Van Buren⁴ and Van Zwahlenburg⁵ have made valuable experimental studies of the subject, the results of which we have utilized.

In this study simple experiments devised to disclose the relation which

exists between intra-intestinal pressure and blood flow through the bowel wall, and which demonstrate the exact effect of various amounts of intra-intestinal pressure upon its viability, motility, secretory activity and power of absorption, have been used; also experiments which show the results of uncomplicated venous obstruction.

*Effects of Distention on the Circulation of the Bowel.*⁶—These can be studied conveniently in the experimental animal by the isolation between ligatures of a segment of intestine in which the intra-intestinal pressure can be varied at will. The ligatures are so placed that they include a stretch of intestine drained by a single vein. The set up of the experiment is shown in Fig. 1.

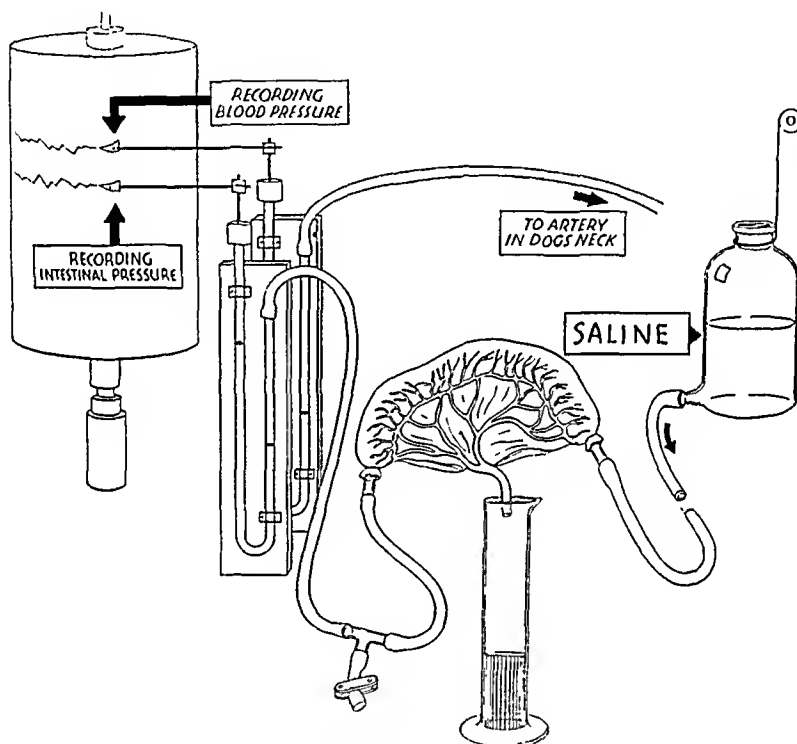


FIG. 1.—Set up of experiment to show effects of distention on circulation of bowel.

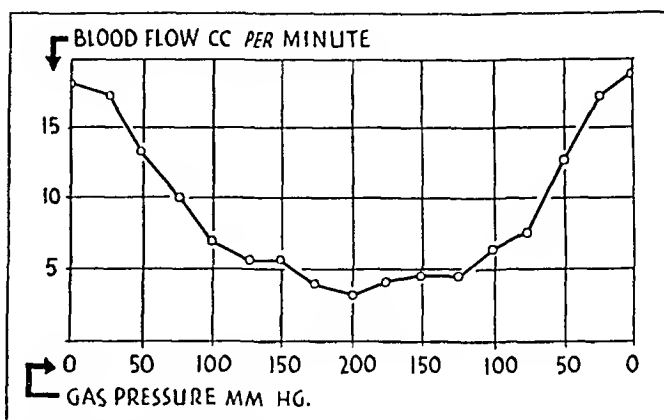
Distention causes a marked blanching of the bowel, which grows paler as the distention increases. We have measured the venous outflow from a segment of intestine, prepared as just described, and have found that it decreases as the intra-intestinal pressure increases, and that it ceases entirely when the intra-intestinal pressure equals the systolic blood pressure. C. A. Dragstedt⁷ has confirmed and amplified this work. Fig. 2 represents a curve obtained by plotting the measured outflow of blood, during equal intervals of time, within each of which the intra-intestinal pressure was maintained at a measured height.

Microscopic study of sections of bowel, fixed with formaldehyde, while inflated to 20 Mm. of mercury pressure, shows that the tissues of the bowel wall have been stretched and compressed, that this deformity affects the

mucosa more than the muscularis, and that the blood vessels of the mucosa are nearly all empty, though the vessels under the peritoneum still contain blood (Fig. 3).

It is evident that the strong submucous coat of the bowel protects the layers of tissue external to it from the full effects of the intra-intestinal pressure. This explains why the anemia of the mucosa is more nearly complete than that of the muscularis.

We conclude from this study that an intra-intestinal pressure as low as 20 Mm. of mercury produces an almost complete anemia of the mucosa of the bowels. It occurred to us that it might be possible to estimate the force of the intra-intestinal pressure by measuring changes in the diameter of a segment of bowel caused by various pres-



CURVE SHOWING THE AVERAGE READING OF BLOOD FLOW IN CUBIC CENTIMETERS PER MINUTE THROUGH INTESTINAL WALL UNDER VARYING DEGREES OF GAS PRESSURE IN THE LUMEN.

FIG. 2.—Curve obtained by plotting the measured outflow of blood, during equal intervals of time, within each of which the intra-intestinal pressure was maintained at a measured height.

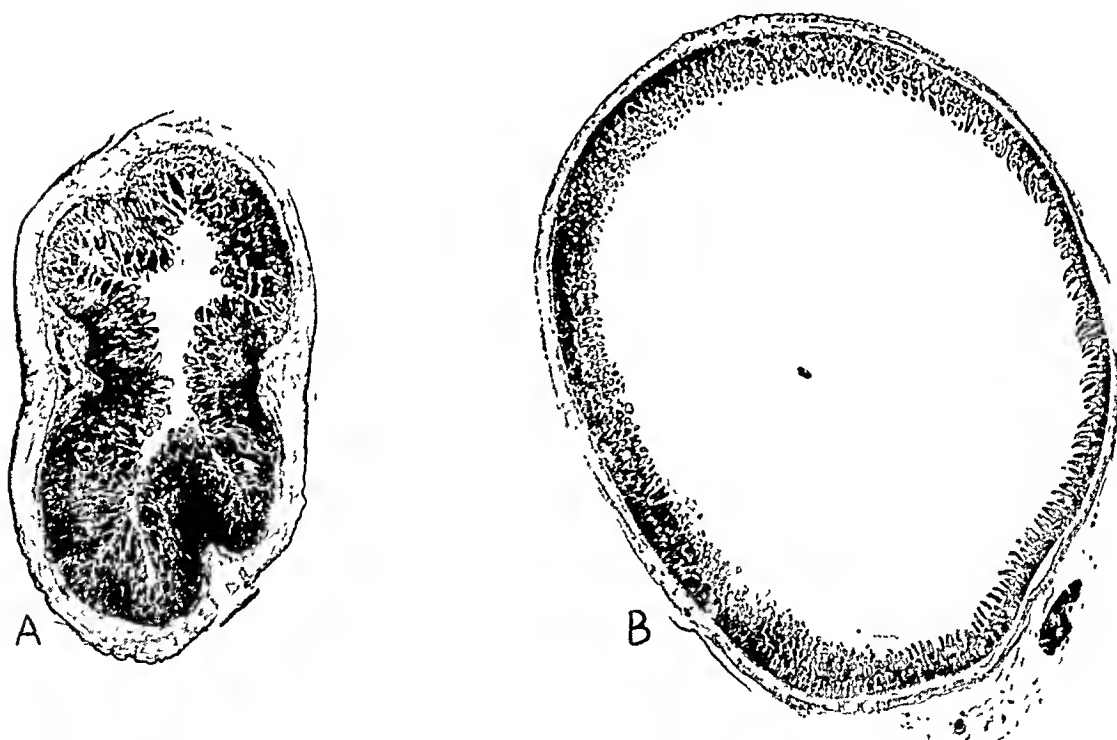


FIG. 3.—(A) Section of bowel inflated with a pressure of 20 Mm. of mercury. (B) Section of uninflated bowel for comparison.

ures. Data so obtained by means of roentgenograms might be of clinical value. To test the accuracy of the method we experimented with a piece of human intestine obtained at an early autopsy. We found that this would be

distended to a diameter of seven-eighths inch by a pressure of only 5 Mm. of mercury and that this diameter was not increased to a measurable extent by any higher pressure up to the pressure which ruptured the bowel. Rupture in one test, in which the pressure was maintained at 125 Mm. of mercury occurred after three hours. In another test in which the pressure was rapidly increased, rupture occurred at 210 Mm. of mercury.

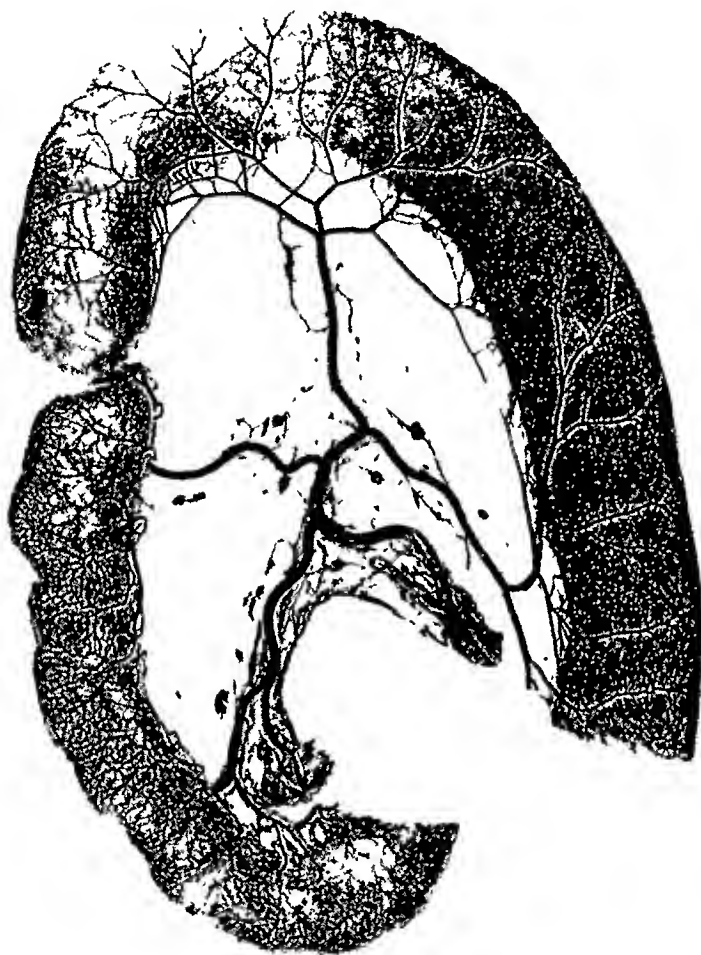


FIG. 4.—Photograph of a piece of bowel, the arteries of which have been injected with bismuth oxychloride; while one part of it was uninflated, the other part was inflated with a pressure of 30 Mm. of mercury. It will be noted that the arteries do not form simple girdles around the bowel, but that they pursue a convoluted course around it. This enables them to accommodate themselves to any increase in the circumference of the bowel without a decrease in lumen due to stretching. The arteries seen in the inflated part are all superficial. Note the complete absence of injected vessels in the end of the inflated part next to the ligature.

In an experiment performed on a dog, we discovered that the intestine, kept within the abdomen, will be slowly distended to several times its normal diameter by a pressure gradually elevated to 60 Mm. of mercury. Bowel so distended is often observed in the human. If the pressure in a bowel which has been stretched in this manner is reduced, the circulation through the bowel wall will be restored, though probably in an impaired condition (Fig. 4).

From these observations, and from our study of the histology of the dis-

tended bowel, we conclude that the demonstration in patients with acute intestinal obstruction of loops of small intestine having a diameter of two or three inches, even though they may be loops of jejunum, indicates that the circulation of the affected loops has been seriously impaired. The stretching to which the intestine has been subjected explains the slow return of peristalsis so often observed, clinically, after the relief of a prolonged obstruction. It also explains why the obstruction may not be relieved by enterostomy or by other means.

Effect of Distention upon Secretion by the Bowel.—We inflated long loops of empty bowel to various levels of pressure, which we maintained from three to four hours. We observed that the peritoneum of the inflated bowel is soon covered by drops of fluid, which is evidently plasma squeezed out of it. We could collect practically no fluid from the lumen of the bowel.

These observations prove that increased intra-intestinal pressure diminishes the secretion of the bowel, and that at constant pressures of over 10–15 Mm. of mercury very little fluid collects in an inflated intestine. When there is no blood in the tissues, they have no fluid to secrete.

Some writers have attributed venous congestion in the bowel to increased intra-intestinal pressure. Our observations do not support this idea, except as it applies to very low pressure. We have never observed congestion of the bowel in experiments in which distention was the only force acting upon the intestinal circulation. It is evident that distention compresses the capillary bed of the bowel wall so that there is a diminished blood flow in the veins. We attribute the congestion of the bowel so frequently observed above an intestinal obstruction, (1) to the pressure of distended loops upon the mesentery loops not so greatly distended; (2) to torsion and stretching of the mesentery whereby the mesenteric veins are partially obstructed; and (3) probably most important of all, to the effect of the partial venous occlusion produced by the two causes just mentioned, in the presence of the greatly increased arterial blood flow which accompanies the vigorous peristaltic action set up in the afferent bowel by rather low intra-intestinal pressure. We have observed some reactive hyperemia after deflation of the bowel. Note that the curve of the blood flow shown in Fig. 2 reaches a higher level at the close of the experiment after deflation than it reaches at the beginning before inflation.

Effect of Distention upon Absorption.—The effect of distention upon the ability of the intestine to absorb is shown by the following experiment:

Into a closed segment of bowel, kept outside the abdomen, and distended by a pressure equal to the systolic blood pressure, a solution of potassium cyanide is injected. No toxic effect upon the animal can be observed. The pressure within the bowel is then gradually reduced. No effect is observed until the intra-intestinal pressure has been lowered to about the level of the diastolic blood pressure. Then the animal immediately shows the effects of the poison.

This experiment proves that absorption from the bowel by way of the mesenteric vessels is prevented by intra-intestinal pressure greater than the diastolic blood pressure.

If the closed segment of bowel, kept inflated by a pressure greater than the diastolic blood pressure, and containing the solution of potassium cyanide, is placed within the abdomen, the animal will show the effects of the poison after an interval of a few minutes. This result, in combination with that of the preceding experiment, proves that transperitoneal absorption from a loop of bowel distended by a pressure greater than the diastolic blood pressure can occur. It is to be noted that transperitoneal absorption of materials not normally absorbed by the bowel will not occur before the mucosa has become devitalized.

We have tested the effect of intra-intestinal pressures between zero and the level of the diastolic blood pressure upon the rate of absorption of alcohol and of sodium bromide by the bowel. These substances were selected because they are readily absorbed, and because their volumetric estimation in the blood can be made with great accuracy. The set up for the experiment was the same as that used to measure the effect of intestinal pressure upon the rate of blood flow through the intestinal wall, except that the segment of bowel was distended by a solution containing 5 per cent of alcohol and 5 per cent of sodium bromide instead of by air.

We found that the rate of absorption remained relatively constant for all gradations of intra-intestinal pressure between zero and the level of the diastolic blood pressure. The rate of absorption depends upon how fast the epithelium of the mucosa can transmit the absorbed substance to the capillaries beneath it. These will carry it away as long as blood is passing through them. The concentration of the absorbed material in the venous blood varies inversely as the volume of blood flow. The absorption of gases from the obstructed bowel requires further investigation (Fig. 5).

Thus for all pressures between 10 Mm. or 15 Mm. of mercury and the level of the diastolic blood pressure the rate of absorption of any material, water and inert gases excepted, normally absorbed by the bowel, is relatively constant. For pressures above the diastolic pressure, transperitoneal absorption occurs, but no absorption by way of the mesenteric vessels.

Enderlen and Hotz¹ discovered that the rate of absorption of solutions containing salt or glucose by the obstructed bowel is much slower than the normal rate. They did not measure the intra-intestinal pressure.

We are at present making an experimental study of the effect of distention on the absorption of water by the intestine, but have not yet come to final conclusions about it. The rate of absorption seems to be governed by the osmotic pressure of the fluid within the bowel lumen, and by the volume of blood flowing through the intestinal wall. Since the mucosa can transfer electrolytes from the bowel lumen to the blood, it can lower the osmotic pressure of the bowel contents to a level at which water will pass from them into the blood. Fig. 6 shows that in the presence of bowel distention there is a great concentration of electrolytes in the venous blood of the bowel wall. This should

favor the absorption of water. The fact that its absorption is diminished must be due to the diminished blood flow caused by distention. When the distention is great enough to arrest the circulation of the bowel, the absorption of water, except by the transperitoneal route, must cease.

Effect of Distention on Motility of Bowel.—If a segment of bowel in the dog be distended with water, and the pressure within it measured by a mercury manometer, the bowel will usually show vigorous peristaltic movements when the manometer registers a pressure of from six to ten Mm. of mercury. These as a rule decrease as the pressure is increased, and cease entirely when the pressure is greater than 30 Mm. Because of the weak musculature of the human intestine, its peristalsis is probably stopped by a much lower pressure.

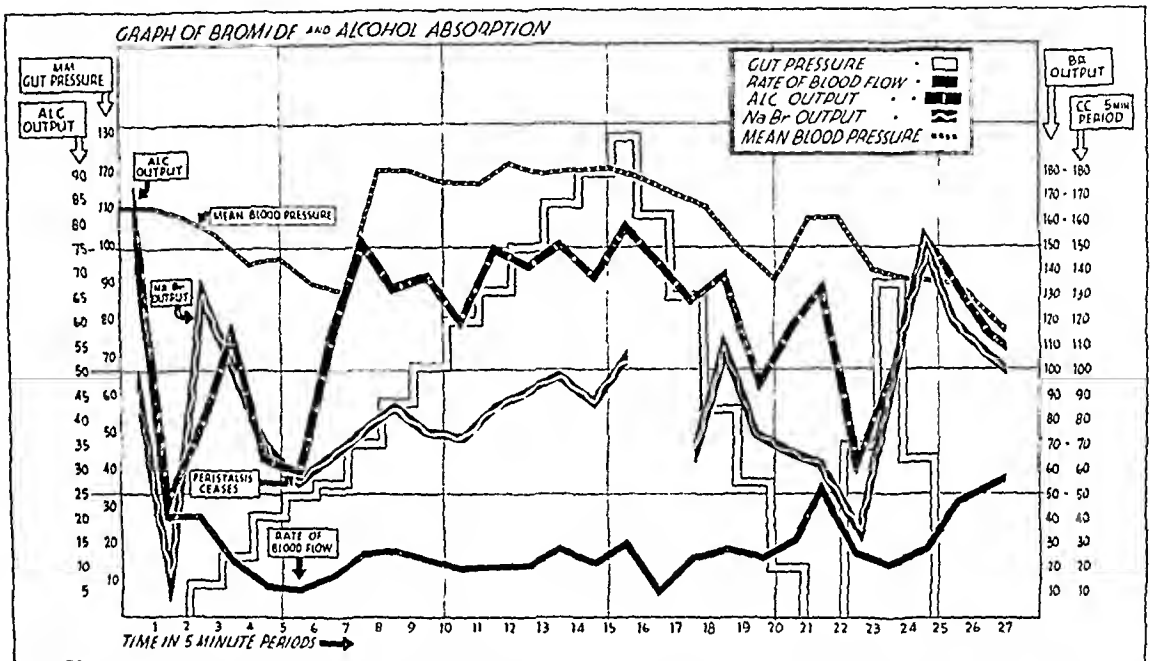


FIG. 5.—Curves showing blood pressure, volume of blood flow, total absorption of bromide and alcohol, and intra-intestinal pressure. The fluctuations in blood flow observed in the early part of the experiment were due to peristaltic action. Note that the curves of alcohol and bromide absorption preserve a fairly constant level without relation to the other curves.

Since it is well known that a totally anemic intestine can contract powerfully, it is evident that the failure of peristalsis, under the conditions of the experiment, is due to stretching of the muscularis, and not to anemia.

Effect of Distention upon Viability of Bowel.—When a loop of intestine is inflated with a pressure equal to the systolic blood pressure, and suddenly deflated, its function seems unimpaired as tested by its power to contract. Furthermore, if a process of alternate inflation and deflation is carried out a number of times, it seems to have no injurious effect on the bowel. We have maintained segments of bowel in an inflated condition under great tension for as long as three to four hours, and have found at the end of this time that they would contract vigorously when pinched; also, that microscopic sections of them showed no demonstrable injury. Carlson and Wangenstein¹⁰ have made the same observation. While these experiments demonstrate that even extreme and prolonged distention injures the bowel surprisingly little,

they do not prove that distention as it occurs in cases of ileus in man does not injure the bowel. Clinically, the distention may be present for many hours longer than it was observed in these acute experiments. Furthermore, prolonged distention, produced experimentally, injures the bowel.⁴

It is a matter of great importance to determine how long a bowel can survive when subjected to an intra-intestinal pressure high enough to arrest its circulation. Fortunately, we have a well recognized method for obtaining this information. Cohnheim states that the power of selective absorption is a property of living intestinal mucosa, which dead mucosa does not possess. By determining how long the mucosa of a detached piece of bowel retains this power, we can determine how long it can survive when deprived of circu-

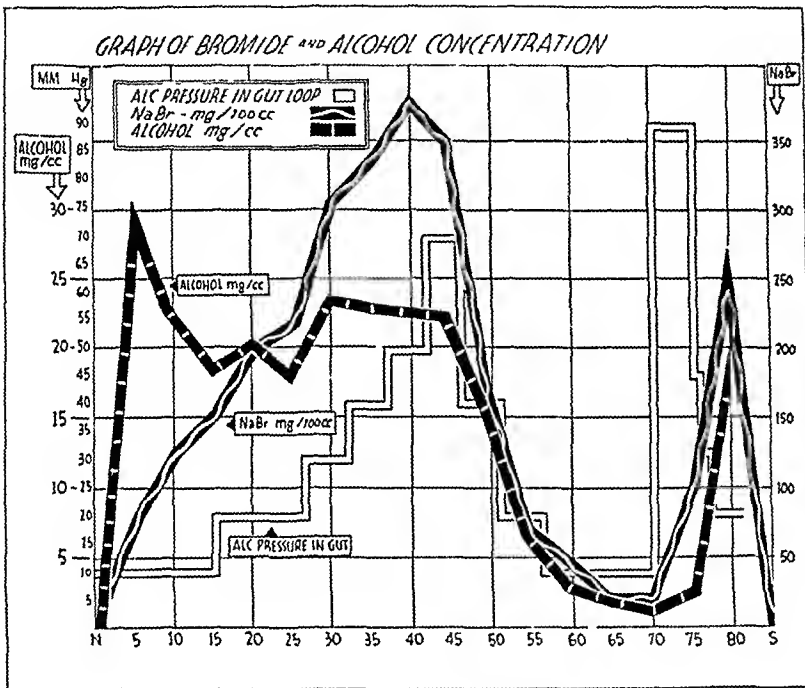


FIG. 6.—Curves showing intra-intestinal pressure and concentration of alcohol and bromide in the blood. It is to be remembered that the rate of blood flow varies inversely as the intra-intestinal pressure. If the rate of absorption remains constant, the concentration of the absorbed material in the blood must increase as the volume of blood flow decreases.

lating blood. The normal intestine will not absorb histamine, proteoses or peptones. We can regard the passage of these substances through the mucosa as proof that it is dead. Dr. J. H. Weatherby of the Department of Biochemistry of the Indiana University School of Medicine has made this determination by means of diffusion experiments on detached rabbit intestine. He reports that this holds back histamine for about five hours and proteoses and peptones for 15 hours, and determined that distention of the detached bowel, living or dead, does not affect appreciably the rate at which substances pass out of it. The circulation of the bowel is stopped by an intra-intestinal pres-

sure higher than the systolic blood pressure, and almost stopped by much lower pressures. It is in essentially the same condition as a detached bowel. We can therefore infer that its mucosa will be damaged after five hours, and entirely devitalized after 15 hours.

In clinical obstruction the afferent bowel is probably not subjected to pressure high enough to damage its circulation until the obstruction has existed for a long time. The bowel may be able for hours or days to empty its contents upward into the stomach and thus keep down the pressure. While the fact that it may be devitalized and rendered necrotic by high intra-intestinal pressure is certain, it is impossible in a given case to determine how long the dangerous pressure has been present continuously.

Experiments Showing the Effect of Interference with the Mesenteric Circulation—Strangulation.—One of the most common types of obstruction observed clinically results from the incarceration of a loop of bowel within the sac of a hernia, or beneath a band, or from torsion of a loop of bowel. The effect of either of these processes is to produce an impediment to the venous return from the loop, while the arterial inflow is not affected.

If a loop of bowel so chosen that its entire venous outflow is through one vein be isolated between ligatures, the vein divided, and the inflow tube of a manometer introduced into the distal end of the vein, it will be observed that the pressure registered by the manometer will shortly be equal to the systolic blood pressure. If the manometer be disconnected, and the experiment be repeated again and again, it will be observed that the manometer each successive time will register a lower and lower pressure, which it will reach after longer and longer intervals of time. This observation shows that the capillary bed of the bowel is subjected to the full force of the arterial pressure when its venous outflow is obstructed. The disastrous effect of this upon the capillaries can be seen when sections of a bowel which have been subjected to this process are studied under the microscope. It is not to be inferred, however, that the bowel cannot recover after having been subjected for some time to venous obstruction. Enderlen and Hotz¹ produced venous stasis in a segment of bowel by ligating the vein which drained it. When the congestion had become so great that blood had been extravasated beneath the peritoneum, they released the ligature. They found that the bowel had suffered no loss of absorptive power. This result harmonizes with clinical observation of the viability of bowel incarcerated in herniae.

Distention tends to protect the capillaries of a congested bowel against rupture because it increases the tension of the tissues around the capillaries. If the intra-intestinal pressure were equal to the systolic blood pressure there could be no venous congestion.

It is evident that early in the process of strangulation a bowel loses its contractility, and power of absorption. Strangulation is accompanied by a great outflow of bloody fluid and mucosal debris into the bowel lumen, and

by the exudation of bloody fluid in the peritoneal cavity. Since its circulation is obstructed, any absorption from a strangulated loop must be transperitoneal. It is well known that the bowel survives occlusion of both artery and vein longer than obstruction of the vein alone.

Effect of Increased Peristalsis and of Perverted Vasomotor Function on the Circulation of the Obstructed Bowel.—These effects are observed in the afferent loops of bowel. Low intra-intestinal pressure causes violent peristalsis which is accompanied by arterial relaxation and increased blood flow. These effects are to be regarded as exaggerations of normal functional activities of the bowel. The increased blood flow caused by low intra-intestinal pressure, in the presence of more or less venous obstruction, due to causes already mentioned, is probably the chief cause of the venous congestion often observed in the bowel above an obstruction. In one experiment (see Fig. 5) in which we were measuring the volume of blood flowing from a segment of intestine, we observed a considerable increase of flow while the bowel was contracting. It is probable that in the human intestine an intra-intestinal pressure of 10 to 15 Mm. of mercury will stop peristalsis. We have already shown that this pressure will decrease the volume of blood flowing through the intestine.

Effect of Increased Intra-abdominal Pressure and of Impaired Systemic Circulation on the Circulation of the Obstructed Bowel.—Increased intra-abdominal pressure theoretically should diminish the volume of blood flow in the obstructed bowel, but probably has very little effect. The reverse, however, is true of the effect of impaired systemic circulation. The low blood pressure and increased viscosity of the blood which are present in advanced intestinal obstruction, impairs still more the already deficient circulation of the bowel.

Effect of Intestinal Distention upon the Intra-abdominal Circulation as a Whole.—With its abdomen tightly closed, we inflated the entire small intestine of a large dog to the level of the systolic blood pressure. This increased the intra-abdominal pressure from zero to only 14 Mm. of mercury, and the blood pressure from 126 to 146 Mm. of mercury. Sudden deflation of the bowel caused these pressures to fall to their former levels. The elevation of the intra-abdominal pressure, because of bowel distention, will of course depend upon the amount of resistance offered by the abdominal walls.

Results of experiments on the intra-abdominal pressure, wherein the abdomen of the dog was distended, by the injection of normal salt solution, to a pressure equal to the systolic blood pressure have been previously published.¹¹ Under these conditions we demonstrated that all circulation through the abdominal viscera ceases, as shown by their being white and bloodless. With lower pressures we found that the intra-abdominal pressure and the pressure in the vena cava remain identical. This shows that the flow through the intra-abdominal veins when the intra-abdominal pressure is high is pro-

duced by the *vis à tergo* of the heart, which is transmitted through the capillaries. These are not ruptured because they are supported by the pressure around them.

It is possible that, under some conditions, the intra-abdominal pressure of a patient might reach a height which would produce considerable anemia of the abdominal organs, and that sudden release of the pressure might produce a failure of the circulation. Nothing of the kind appears in acute experiments on dogs, and we have never observed its occurrence in man, but it has been reported.¹²

Apparently the chief harm done to the circulation by increased intra-abdominal pressure is produced indirectly by interference with respiration and heart action.

Effect of Intestinal Obstruction upon the Systemic Circulation.—The discovery by Hartwell and Hoguet¹³ that the parenteral administration of sufficient salt solution will prolong life greatly in the presence of intestinal obstruction is probably the most important contribution ever made to our knowledge of this disease. Preceding investigators had discovered that the body loses considerable fluid because of bowel obstruction, but Hartwell and Hoguet first recognized the great magnitude of this loss, and grasped its theoretical and clinical significance. Their discovery has finally led to the demonstration, now accepted by everyone, that the chief cause of death in simple obstruction of the small bowel, which in man usually means high obstruction, is circulatory failure due to loss of water and electrolytes by the blood. Death from this and from all other forms of obstruction was formerly attributed to the absorption of poisonous material from the bowel. This intoxication theory,¹⁴ though now restricted in scope, is still believed to account for many of the systemic effects of all forms of obstruction which have *injured* the bowel. It has had great influence upon research and treatment, though its truth has never been proved. Many writers have pointed out that the crucial test of the proof must be the demonstration that toxic material is actually absorbed from the obstructed bowel.

The proof has been sought by many methods, but chiefly by methods designed to demonstrate the presence of toxic substances in the blood and lymph of animals with bowel obstruction. L. R. Dragstedt¹⁵ has recently pointed out that poisons are so quickly neutralized or fixed by the body that attempts to recover them from the body fluids are likely to be failures.

Our experiments have enabled us at least to delimit the problem accurately. The following conclusions regarding its present state seem justified:

1. There are two possible ways for toxic material present in the lumen or wall of the obstructed bowel to reach the systemic circulation: (1) By way of the mesenteric vessels. (2) By way of the peritoneal cavity.

2. Before the passage of *any* toxins which we can imagine to be present by either route or under any conditions can occur, injury to the mucosa must exist.

3. Injury observed under clinical conditions to the mucosa of the obstructed bowel is due practically to two causes only: (1) Distention. (2) Venous congestion.

4. Any passage of toxins from a bowel with devitalized mucosa must be transperitoneal as long as its circulation is stopped by pressure or obstruction; by way of the mesentery if its circulation is present.

Clinical Importance of Transperitoneal Absorption.—Since various kinds of toxic material readily diffuse in vitro through the bowel wall after its mucosa has become devitalized, it is to be inferred that they do so under clinical conditions characterized by injury to the mucosa and arrest of the circulation by distention or venous obstruction.¹⁶ There is good reason to believe, however, that the inflammatory reaction of the peritoneum around the affected loops can prevent the passage of the toxic material into the systemic circulation. The work of David and Sparks¹⁶ on the protective action of peritoneal exudates gives strong support to this belief. It is also supported by the clinical observation of loops of bowel which evidently have been gangrenous for many hours and have caused no noteworthy systemic disturbance. The peritoneum probably can isolate a devitalized bowel as readily as it can on abscess.

Clinical Importance of Absorption by Way of the Mesenteric Vessels.—It follows, from the foregoing, that, under clinical conditions, the only time at which absorption of toxic material by way of the mesentery can occur follows the relief of venous obstruction or the relief of distention. This restores the circulation of the bowel and permits the blood to carry away any poison which has passed through the devitalized mucosa. Elman¹⁷ has recently produced clinical evidence in support of the absorption of toxins under these conditions.

The blood flow through a strangulated bowel after the relief of the venous obstruction is probably so slowly reestablished that it carries toxins away gradually and in small amounts only. This idea is supported by the usual behavior of patients following the reduction of strangulated herniae. The sudden relief of the prolonged distention of long loops of bowel is theoretically a more serious matter.

CONCLUSIONS

(1) In clinical intestinal obstruction, injury to the bowel is due chiefly to distention and venous obstruction.

(2) Distention causes a decrease in the blood flow through the bowel wall, which is in direct proportion to the elevation of the pressure. It almost stops the blood flow when it reaches the level of the diastolic blood pressure. At this level it stops all absorption by way of the mesentery. Transperitoneal absorption then occurs.

(3) Distention sufficient to arrest the circulation of the bowel will devitalize the intestinal mucosa in from five to 15 hours. This devitalization is demonstrated by the loss of selective absorption by the mucosa. It

then permits the passage of toxic substances present in the normal and obstructed bowel.

(4) The absorption of materials normally absorbable by the bowel, except water and probably inert gases, proceeds at a relatively uniform rate in the presence of intra-intestinal pressures between zero and the diastolic blood pressure. Final conclusions on the effect of distention on the absorption of water and inert gases have not been made.

(5) Venous obstruction subjects the capillaries of the bowel to the full force of the systolic blood pressure. This accounts for its rapid destruction of the bowel wall.

(6) The circulation of the obstructed bowel is not greatly influenced by the increased intra-abdominal pressure which accompanies intestinal obstruction. The blood flow through distended loops must be lessened by any weakness of the systemic circulation.

(7) The conditions under which toxins can be absorbed from the obstructed bowel are stated, and the conclusion reached, that the body is protected in a fairly adequate manner from absorption of toxins by way of the peritoneum; also the conclusion that the sudden relief of obstruction in the presence of devitalized mucosa may permit the rapid absorption of toxic substances by way of the mesentery.

(8) In the clinical management of patients suffering from advanced obstruction, it seems desirable to deflate the bowel gradually before the operative relief of the obstruction is undertaken. Otherwise the barriers against absorption of toxins by way of the peritoneum, and against their rapid absorption by way of the mesentery, may be broken down.

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DISCUSSION.—DR. FREDERICK T. VAN BEUREN (New York, N. Y.).—The author's experiments are particularly interesting to me in view of some recent work that we have been doing to test the comparative toxicity of normal and obstructed intestinal contents. It is merely repetition of work that has been done before, a good many years ago, by a number of French and German investigators, and resulted in confirmation of their claim that the normal intestinal contents were just about as toxic as the obstructive contents.

If that is true and you have poison existing in the intestines before obstruction, why should it be absorbed after the intestine is obstructed and not before?

This work of Doctor Gatch is particularly timely and instructive from that point of view because he has shown so clearly the conditions under which absorption takes place and why. If there were some way in which we could remedy the situation, relieve the pressure under which mucosa is injured by the shutting off of its blood supply, we would have solved the problem of the treatment of intestinal obstruction.

It is important that the relief of the distention be made gradually, so as to prevent the absorption of poison with the released circulation after the mucosa has been injured by the prolonged distention. Whether we do that by a tube from above or from below, as he has pointed out, it is not effective unless the intestinal wall is still sufficiently viable. It is again another argument for the only really good treatment of intestinal obstruction which is early diagnosis and early operation to prevent the injury to the bowel.

DR. THOMAS G. ORR (Kansas City, Kans.).—Doctor Gatch has quite ably presented the physiologic and pathologic changes which take place in overdistention of the gut when the bowel is obstructed. I think it is, of course, obvious to everyone that we cannot cure intestinal obstruction until we have relieved the obstruction, but we can render considerable assistance by taking into account the physiologic and pathologic changes that take place during the progress of the disease, especially in simple occlusion of the gut.

It is probable that there are two lethal factors in simple obstruction, disregarding, of course, the strangulation of the bowel which adds still another. These two factors are the loss of essential secretion from the upper intes-

tinal tract and overdistention which Doctor Gatch has discussed. We have a means of eliminating in a measure the first, by supplying chlorides and liquids to replace those which have been lost by the disease. In the second situation, we have a condition which is a little more difficult to overcome, but we can assist by relieving the pressure within the gut mechanically with the suction apparatus which has been so ably presented by Wangensteen, and by enterostomy in selected cases. In addition we also may aid in maintaining the bowel tone during the height of the disease. We know that salt will stimulate peristalsis in concentrated solutions and there is no reason why we should not believe that, if maintained at the normal level in the body, it will aid in maintaining the tone of the gut. In addition to salt, we may assist in maintaining the tone of the gut by keeping the patient continuously morphinized. If the bowel is kept stimulated we may, during that stage of distention or beginning of distention, prevent to some extent the overdistention until we can relieve the obstruction.

Morphine, as you know, stimulates the tone and rhythmic contractions of the intestine. As long as there is activity of the gut, certainly there can be no absorption of toxins. In other words, the gut that still maintains its activity will absorb those things it should absorb and not absorb those things that it should not absorb.

DR. JACOB FINE (Boston, Mass.).—There are three sources from which gases causing bowel distention are derived.

Some ten years ago, McIver, in a clinical study, demonstrated that at least in postoperative patients swallowed air accounted for the major portion of the distending gases and recommended the use of an inlying stomach tube as a prophylactic for intestinal distention.

From some recent experimental studies done at the Beth Israel Hospital, we have concluded that the type of food ingested will account for some of the intestinal gases. Thus pure proteins and fats such as lean meat, gelatin, olive oil, *etc.*, do not generate significant volumes of gas in a closed loop consisting of stomach and small intestine. Similarly certain carbohydrates such as cooked cereals and toast are innocuous. But liquid carbohydrates, such as orange or grape juice, milk, custard and puréed vegetables, such as lima beans, are especially rich sources of gas formation. Of the gases which are generated in the gastro-intestinal tract CO_2 , H_2S , O_2 and CH_4 are of little consequence in distention because the first two, CO_2 and H_2S , are absorbed very rapidly unless the circulation of the bowel wall is badly damaged, while the latter two, O_2 and CH_4 , are almost never found by analysis to constitute more than an insignificant percentage of the volume of distending gases. N_2 from swallowed air and H_2 formed from the fermentation of foods constitute the bulk of the distending gases because they are not readily absorbed by the blood stream. The amount of H_2 in any given instance will depend on the type and quantity of food in the intestine at the moment when peristaltic activity becomes inadequate for the expulsion of intestinal contents.

The third source of gases in the intestine is the nitrogen in physical solution in the blood. This nitrogen diffuses into the intestine from the blood until the partial pressure of nitrogen in the intestine reaches the same level as exists in the blood. When the intestine becomes inflated by nitrogen from swallowed air its pressure within the intestine is already equal or greater than it is in the blood. But any stretching of the bowel lumen by other gases such as H_2 decreases the partial pressure of nitrogen in the intestine and so facilitates the entrance of further nitrogen into the gut from

the blood. This third source of nitrogen will not enter as a factor so long as the intestine contains no food. Experimentally we have repeatedly found that if a starved animal has the cardia and ileocecal valve ligated, no gas will accumulate in the stomach or small intestine. Consequently the ideal treatment for the avoidance of intestinal distention is (1) to use a stomach tube to prevent swallowed air from entering the duodenum; and (2) to avoid gas forming foods.

In the treatment of established distention which has failed to yield to the ordinary methods in common use, we have made use of an experimental observation by McIver to the effect that the absorption of nitrogen from the intestine can be accelerated by causing the animal to breathe pure oxygen. This is based on the well substantiated belief that nitrogen is the chief gaseous constituent of the distended bowel. The exclusion of nitrogen from the inspired air results in a rapid reduction of the pressure of nitrogen in the blood with a corresponding increase in the speed of diffusion of nitrogen from the intestinal lumen into the blood. We have applied this principle to eight patients with obstinate distention and believe we have accomplished a significant deflation of the gut. The use of pure oxygen for this purpose must be resorted to with due regard for its toxic properties, which can be avoided.

Of course, the principle underlying the use of oxygen would apply for the removal of incarcerated air anywhere in the body. We are now attempting to utilize the method for the relief of symptoms following the introduction of air into the ventricles for encephalographic examination. Preliminary observations so far are quite encouraging and we have roentgenologic evidence showing the absorption of air from within the cranium under these circumstances. The application of the principle for the relief of subcutaneous emphysema and for certain types of pneumothorax might also be considered.

In connection with Doctor Gatch's statement regarding the failure of fluid to accumulate in a loop of gut distended with air, we have repeatedly distended collapsed loops of gut with various gases under considerable tension and within 12 to 24 hours have frequently recovered variable quantities of fluid.

As to the viability of the gut distended with gas we can state from our experimental observations that loops of gut so distended under pressure equal to or exceeding what is encountered in long standing obstruction may remain perfectly viable after 24 hours even though the pressure remains high.

DR. OWEN H. WANGENSTEEN (Minneapolis, Minn.).—The very splendid paper of Doctor Gatch could not be discussed with justice in a few minutes. My colleagues and I have experimented along somewhat similar lines and by and large our results are much the same. When the bowel is obstructed, it shortens, increases in weight, and its strength diminishes. The stress upon the bowel wall in obstruction may readily be calculated from the formula—stress or tension is equal to the circumference of the bowel multiplied by the sustained intra-enteric pressure, or $T = D \times P_i \times P_r$. We have determined the intra-enteric pressures in established obstructions of the small bowel in about 40 dogs. Similarly, the intra-enteric pressure has been measured in several instances of obstruction of the small intestine at the time of performance of enterostomy and upon the obstructed colon, when decompression was established by colostomy. In the experimental obstructions of the small intestine a mean sustained intraluminary pressure of about ten cm.

of water was observed—a finding in keeping with the intra-enteric pressures noted in instances of clinical obstruction of the small intestine. Occasionally, intra-enteric pressures as high as 16 to 18 cm. of water were encountered. In clinical obstructions of the colon with considerable distention, on the contrary, high intra-enteric pressures are the rule. Pressures varying between 12 and 52 cm. have been observed with a mean value of about 24 cm. The proximal competent ileocecal sphincter makes of the colon a virtual closed loop, in which loop a high pressure usually develops.

In this behavior lies a fundamental difference in the manifestations and sequence of events which attend obstructions of the small intestine as distinguished from those in the colon. In obstructions of the small intestine, regurgitation occurs into more proximal reaches of the bowel and also the stomach. In consequence, vomiting is a prominent feature. Because of the participation of several loops of bowel in the distention, the intra-enteric pressure is not as high as it would be, were the distention confined to a relatively short segment, as it is in the obstructed colon. When a duodenal tube is passed into the stomach, when the small bowel is obstructed, a high grade of gastric retention is usually found.

When the colon is acutely obstructed, there may be no vomiting despite enormous distention. In a patient exhibiting intestinal colic with considerable distention, but no vomiting, obstruction of the colon is to be suspected. Fecal-like vomiting denotes obstruction of the small intestine.

The hazard borne by a patient with an obstruction of the colon is immediately apparent in the stress upon the bowel wall. There often is no fluid loss in such a patient and gastric retention is rarely found. The administration of saline solution, which is so helpful to patients with high obstruction of the small intestine in which the fluid loss is great, has no particular virtue in colonic obstructions. Frequent vomiting in small bowel obstructions helps to reduce the intra-enteric tension and consequently the stress upon the bowel wall. The obstructed colon may perforate even though the patient does not appear especially ill.

The clinical axiom that the high small bowel obstructions are the most dangerous should be altered to read: "Low obstructions are the most treacherous for they carry the greater hazard for the safety of the bowel wall." Apart from the item of fluid loss, which concerns essentially only high small bowel obstructions, the important consideration is relief of the obstruction before the viability of the bowel wall has become impaired.

MESENTERIC VASCULAR OCCLUSION

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OCCLUSION of the mesenteric vessels may involve the arteries or veins, or both. In an analysis of 36 cases on which autopsies were performed, reported from the Mayo Clinic by Larson¹ in 1931, the occlusion was arterial in 39 per cent, venous in 44 per cent and coexistent venous and arterial in 17 per cent. The occlusion may occur in the main stem of the vessels, in a branch supplying one intestinal loop or in the vessels close to their distribution in the intestinal wall. A vascular lesion may be due to a thrombus or an embolus, or a thrombosis and an embolism may occur in combination. The closure of the vessel may be complete or incomplete. If the obstruction to the circulation is sufficient to destroy the blood supply of the intestine, it results in gangrene of the intestinal wall. If it is not complete a hemorrhagic infarction may occur in the intestinal wall and mesentery, which may progress and may eventuate in gangrene; or the circulation may be reestablished with recovery. Anemic infarct rarely occurs.

Although occasional reports appear in the medical literature of cases of vascular mesenteric occlusion which recover spontaneously after nothing more has been done than an exploratory operation, and also reports of recovery after very extensive intestinal resection, the mortality is frequently said to be in the neighborhood of 90 per cent. Therefore, quite naturally, the prognosis in all cases is a gloomy outlook.

It is obvious that an occlusion of the main stem or branch of the superior mesenteric artery or vein, which would destroy the blood supply to a large portion of the small intestine, would give small opportunity to effect a surgical cure. If it is recognized that in a certain proportion of cases the occlusion occurs in one of the smaller terminal branches, allowing a resection, then a cure in such patients may be effected.

A review of the case histories of this disease from the records of St. Luke's Hospital was prompted by a recent case, in which not only a positive diagnosis of mesenteric thrombosis could be made, but also the location and the extent of the lesion was demonstrable by a plain roentgenographic film of the abdomen, and the operation showed that previous to the attack an earlier incomplete occlusion had occurred, or the circulation had been reestablished.

There were 11 patients whose histories were filed under the diagnosis of "mesenteric vascular occlusion." Of these, seven died and four recovered. A resection of the intestine had been performed upon three of the four who recovered. In the fourth patient, while there was bloody fluid in the peritoneum and a hemorrhagic area in the base of the mesentery, the circulation of the intestine did not appear to justify a resection. In the seven fatal

cases a resection was done in one only, an ileostomy in one, and no operative procedure was performed in the others.

A comparison of 36 pathologic reports, published in Larson's¹ article, with the limited number of autopsy reports or examinations of removed specimens in St. Luke's Hospital, is of interest. In Larson's series a vascular occlusion was noted in every case. In the St. Luke's Hospital series this was not so. In one case in which postmortem examination was performed, there was gangrene from the beginning of the jejunum to and including the cecum and appendix. The pathologic report stated that: "There is marked constriction about the opening of the superior mesenteric artery and celiac axis which contained some atheromatous patches. No thrombosis is present in the superior mesenteric artery or vein." In a second case the report stated that: "The intestine is necrotic and sections showed infarction and hemorrhage, but the arteries do not contain thrombi (32 cm. of small intestine had been removed in this patient)." In a third case: "Postmortem shows that four feet above the ileocecal valve there is a V shaped area in the mesentery about 4 centimeters wide with areas of hemorrhage and edema. The intestinal wall is hemorrhagic but not necrotic. The vessels apparently are patent, and there are multiple subserous hemorrhages of the small intestine (an ileostomy had been performed on this patient)." In a fourth case, in which 18 feet of small intestine were resected, examination of the specimen removed showed that the intestine had areas of subserous hemorrhage, but apparently the vessels were normal, not showing thrombosis or any evidence of the etiologic factor of the process. In two cases, one of which recovered, one of which died, there was a thrombosis of the mesenteric vessels.

These pathologic reports, showing no gross thrombosis or embolism in the larger vessels, although there was gross damage to the intestinal wall, would suggest that in a certain number of cases the infarction began in the smaller vessels, either close to or in the vessel wall, in some instances perhaps being due to an anaerobic infection originating in the intestine itself. It also is of interest in making this comparison of the small group of cases from St. Luke's Hospital with Larson's group from autopsy reports, that the former were operated upon for primary vascular occlusion while five of the latter group were complicated by extension of an infective process in the appendix with development of a septic thrombus into the tributary veins. There were also two postoperative occlusions following intestinal obstruction, in which the thrombus resulted secondarily to damage to the intestine or its mesentery.

An examination of the St. Luke's histories suggested nothing which would aid in making a preoperative diagnosis any easier. A recognition of what are known to be the etiologic factors in mesenteric vascular occlusion, such as an arteriosclerosis, atheroma, cardiac disease or aneurysm, abdominal trauma, a previous history of phlebitis or polycythemia, or a chronic sepsis, might suggest that in the presence of acute abdominal symptoms mesenteric

occlusion was the causative factor. But it is questionable whether a correct preoperative diagnosis is made any more frequently now, than when Trotter in 1913 analyzed 360 cases in which he stated that the preoperative diagnosis was made in only 13.

One would expect to find these lesions occurring in the later age groups where arteriosclerosis is common, but cases have been reported where the patients were eight, ten and twelve years old, and one case at four months. A chronic sepsis may be the etiologic factor and in one case from the St. Luke's series, a complete mesenteric thrombosis occurred following an abdominal contusion five months after a splenectomy had been performed for Banti's disease.

However, one would not expect to be able to formulate a definite symptom complex when the pathologic condition may vary from an occlusion causing extensive interference with the circulation of many feet up to the entire length of the small intestine; or only affect one small loop; or where the vascular occlusion may be immediate in its result or, in other cases, progressive. In the majority of instances the symptoms will be those of an acute abdominal catastrophe, indicating an exploratory operation, and the abdominal pain, which is a predominant symptom of all such cases, would be common to a mechanical obstruction, a volvulus, an intussusception, a malignant lesion, rupture or perforation of an abdominal viscus or an acute pancreatic necrosis.

It is unnecessary here to recapitulate the percentage of frequency of the various other accompanying symptoms, which have been carefully analyzed and reported in an article by Meyer in 1931. When the symptoms, which point to an acute abdominal catastrophe, are a high leukocyte count together with acute abdominal pain, a previous history of thrombosis or a source of embolism, an early subnormal temperature, abdominal rigidity and melena, one has a definite group of symptoms pointing to a mesenteric occlusion. However, Meyer in his review of 92 proven cases—which had been reported during the previous ten years—states that melena is reported in only 14 per cent of the cases and that in three of these it did not occur during the first 24 hours, in one instance not appearing until the twelfth day. The same thing applies to rigidity which may or may not be present, depending on the amount of bloody fluid exudate which occurs. In none of the 92 cases was a radiogram to determine the presence of gas recorded. A definite preoperative diagnosis rarely can be made in the early stage of the disease, beyond the recognition of an acute abdominal lesion requiring an exploratory operation, except in the very favorable case such as is reported in this article.

Having determined that an exploratory operation is indicated, it becomes necessary to recognize the abdominal lesion present, or in the process of development, and to determine the operative treatment indicated. It must be recognized that recovery may take place in what appears to be a badly damaged loop of intestine. Also it must be recognized, especially in cases where there is thrombosis in the veins, that if no resection is done the thrombosis may progress and result in further intestinal damage. Cases are re-

ported from autopsy where the condition was not recognized at operation, perhaps because there was an early stage of a progressive lesion, which went on to a fatal termination.

The color of the intestine alone is insufficient to determine its viability. It may be of some assistance to puncture a small vessel in the mesentery near the intestinal wall with a needle to see if blood still escapes from the needle prick, and careful observation of the circulation of the mesentery will be a valuable guide to determine the point of resection. Cases are recorded where apparently extensive damage to the whole small intestine was present and where without resection the patient has recovered. This can be explained only by the fact that there was a mistake in judgment as to the extent of the damage, or recognition of the possibility of restoration of the circulation. Other cases are recorded where recovery has occurred after very extensive intestinal resections.

In the series of 92 cases reported by Meyer, there was a gross mortality of 57.6 per cent, but in 43 of these cases in which partial resection was done the mortality was 32.6 per cent. In 11 cases examined from the St. Luke's series the mortality was 63.6 per cent, one case having recovered without any operative procedure beyond an exploratory operation, but in the four in which resection was done three recovered, making a mortality of 25 per cent.

In a number of cases reported in the literature either an enterostomy or an exteriorization was done. These procedures have little to recommend them. If the occlusion is sufficient to damage the intestine, the enterostomy will not remove the area which is going on to necrosis and become gangrenous and, even apart from this, Mason has called attention to the potency of fresh tissue extract in the production of intravascular coagulation (thrombosis or embolism). As to exteriorization, if all of the loop can be brought out of the abdominal cavity to be exteriorized, very little more time would be required with additional strain on the patient to remove the diseased portion and to perform an anastomosis and at the same time to excise the thrombosed mesentery and prevent the extension of the thrombosis. The reports of cases from the literature confirm these theoretical considerations. Therefore it would appear that, both from a theoretical viewpoint as well as from case reports, where possible a resection and immediate anastomosis should be done. As there are symptoms of obstruction in these cases without occlusion of the intestine, one does not find a large, dilated loop above the portion of the intestine resected with a small, contracted loop below and, therefore, this difference in caliber of the intestine does not have to be considered. Having determined the extent of the damage to the bowel and by careful examination of the mesentery how far the thrombosis or damage to the mesentery has extended, a resection of the damaged bowel and its corresponding mesentery should be done, with immediate anastomosis by the aseptic method.

A report of the following case is of special interest because, as before stated, the previous history, the presence of blood in the stool and the

plain roentgenogram, demonstrating the loop of the intestine involved, made possible a preoperative diagnosis not only of mesenteric thrombosis but determined the site of the operative incision, location of the lesion and extent of the bowel involved; and demonstrated at operation an area which previously had been the seat of a thrombosis of the mesentery, with return of the circulation and recovery of the intestinal wall.

CASE REPORT

L. R., male, age 37. Admitted to St. Luke's Hospital March 27, 1934. He had been operated upon in another hospital the previous January for appendicitis. This was followed by a pulmonary infarction and later by a double femoral phlebitis. He remained in the hospital until the early part of March when he returned to his home.



FIG 1—Plain roentgenogram film showing loop of damaged small intestine in left lower quadrant

Shortly after his return home he began to have lower abdominal pain which gradually became more severe, was accompanied with distention and vomiting and signs of a partial obstruction. These symptoms gradually became more severe up to the time of his admission to St. Luke's Hospital. There were no signs of an acute obstruction and a plain roentgenogram of his abdomen on admission showed a general distention of both the small and large intestine. His preoperative temperature ranged from $98\frac{2}{5}^{\circ}$ to $100\frac{4}{5}^{\circ}$ and at the time of operation was $98\frac{2}{5}^{\circ}$. On the morning of April 1 his pain became more severe, tenderness more marked and an enema was followed by a very considerable amount of blood in his stool. The plain roentgenogram (Fig. 1) of his abdomen taken at this time showed a somewhat contracted loop of intestine in his left lower quadrant, and there was some rigidity and marked tenderness over this area. A

diagnosis of thrombosis of the mesentery with damage to the intestine was made. He was operated upon immediately under spinal anesthesia. The incision was made in the left lower rectus region, which had been indicated both by tenderness and the roentgenogram. Upon opening the abdomen, there was some bloody peritoneal fluid found, and a loop of the ileum about 60 cm. in length, which was dark red to deep purple in color, was delivered. The mesentery was very much thickened and the vessels contained thrombi down to the base of the mesentery. Ninety-five cm. of intestine were removed leaving 15 and 18 cm. of normal intestine at each end. A corresponding section of mesentery was removed, and it was of interest that, on removal of the clamp from this portion of the mesentery, it could be seen that all of the veins were occluded by thrombi. An end-to-end anastomosis was done by the aseptic method. On examining the intestine above and below the damaged area there could be seen a second area about 30 cm. below the area previously described, which was thickened and grayish and resembled a loop of intestine which had been partially occluded in a strangulated hernia. On holding the mesentery of this loop up to the light there could be seen apparently newly formed vessels and it was evident that this area previously had been damaged by a thrombus during the period of two weeks when he first had his symptoms at home, which resembled a partial obstruction and from which he had recovered previous to the development of this new thrombosis. The patient had a stormy convalescence and at times it appeared that he might be developing new thrombi. He finally recovered and left the hospital on June 6 and has had no symptoms since then.

The pathologic report showed that the blood vessels were blocked with septic thrombi, there were no changes in the arteries, and that the obstruction of the veins was evidently due to infection.

No blood culture was taken, but after operation when it was feared that he was developing further thrombosis his bleeding time was $2\frac{1}{2}$ minutes, coagulation time $4\frac{1}{2}$ minutes. Blood calcium 10 and blood phosphorus 3.8. All normal values. During this time he was on a diet low in protein and calcium and high in carbohydrates. Whether this influenced his convalescence cannot be determined.

SUMMARY

An examination was made of the histories of 11 cases of mesenteric vascular occlusion from the records of St. Luke's Hospital. Of these, seven died and four recovered. A comparison of the pathologic findings from specimens which were removed or autopsy reports was made with a report of 36 autopsy studies from the Mayo Clinic, reported by Larson. The difficulty of formulating a definite symptom complex in a condition in which the pathologic lesion may be so different is called attention to, and also an attempt is made to call attention to those symptoms which, in the presence of an acute abdominal catastrophe, would indicate the probability of mesenteric vascular occlusion.

More favorable mortality statistics, both from the literature and from the small group of cases reported from the St. Luke's Hospital records, would seem to indicate the advisability not only of an early operation but of the carrying out of an immediate resection and anastomosis rather than an ileostomy or exteriorization as a palliative measure.

A case is reported which gives a previous history of thrombosis and which later developed blood in the stool, and in which a plain roentgenogram demonstrated the loop of intestine involved which not only made a preoperative diagnosis possible, but determined the location of the operative incision and the extent of the bowel involved. Operation also demonstrated the site of

a previous incomplete vascular occlusion to another loop of intestine, in which circulation had been reestablished.

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DISCUSSION.—DR. HENRY W. CAVE (New York). Doctor Douglas has stated that in addition to circulatory diseases such as arteriosclerosis, atheroma, aneurysm, and endocarditis, trauma is an important etiologic factor in mesenteric vascular occlusion. He also brought out the point that it is very important to make thorough roentgenographic studies of these cases before operation, all of which I am in accord with.

I should like to recite a case where a preoperative diagnosis of mesenteric thrombosis was made which was due to trauma. A man of forty-two, a splendid athlete and a famous polo player, complained of distress in the right upper quadrant of his abdomen, with increasing distention. His previous history was unimportant except he had had an appendectomy in 1908 and typhoid fever in 1913. His present illness began on June 9, 1931, just four years ago.

While attempting to lift up the rear end of a stalled automobile, he experienced a sudden pain in his abdomen with a feeling as though something was giving way. He walked back to the house, crawled through an open window and lay on the floor all night. The only comfort he obtained at all was when he crawled around on his hands and knees. He became rapidly more ill and his abdomen became more distended. I saw him three nights and two days following the onset of his illness. At that time his abdomen was markedly distended. There was a scar of his previous operation. He was tender; there was visible peristalsis. A diagnosis of intestinal obstruction was made, due possibly to an intraperitoneal band at the site of his old appendix wound. This was later altered after examination at the hospital to a diagnosis of mesenteric thrombosis.

At operation the last four feet and nine inches of his ileum was practically black, deep purple. The leaves of the mesentery had been forced apart and were tremendously swollen by the influx of blood. The intestine was resected and an end-to-end anastomosis with a proximal enterostomy performed. He made a satisfactory recovery.

Another extraordinarily extensive mesenteric vascular occlusion was found in a woman, 48, a patient of Dr. William C. White's, who had suffered from thyrotoxicosis, with an enlarged heart, endocarditis and a history of 24 hours of severe abdominal pain with nausea and vomiting.

She, too, had been operated upon for some abdominal condition and appendix some years ago. We considered the diagnosis of band with obstruction or, more likely, mesenteric thrombosis. She was operated upon immediately and an extraordinarily extensive dry gangrene was found starting about six inches below Treitz' ligament, throughout the entire small intestine, through the ileocecal valve, head of the cecum, and quite far up the ascending colon. She died shortly afterward.

A partial autopsy demonstrated a saddle thrombus in the superior mesenteric artery, at the ileocolic branch, which hardly seemed to account for the very extensive dry gangrene of this part of her small intestine, but such was the case.

A third interesting case (courtesy of Dr. H. A. Patterson) was that of a young boy, 22, who had had an acute gonorrheal arthritis with epididymitis for five weeks. He ate a big meal one night and became desperately ill. On entrance to the hospital, a mass in the right lower part of his abdomen was apparent. He passed some blood, was nauseated and vomited. A diagnosis of intussusception was made. At operation he showed a most interesting segmental area of gangrene in the ascending colon above the head of the cecum. A colectomy was performed, side-to-side anastomosis. He made a satisfactory recovery.

At Roosevelt Hospital we have had 12 cases of mesenteric vascular occlusion proved at operation. Four lived, eight died, a mortality rate of 66.6 per cent. I should like to say I agree heartily with Doctor Douglas' statement that the operation of choice in this condition is certainly immediate resection and preferably enterostomy above. I think any other operations usually prove fatal.

DR. EMMET RIXFORD (San Francisco, Calif.).—There are several possible etiologic elements that apply to individual cases of mesenteric vascular occlusion. We have opened the abdomen a number of times and found local congestion of the small bowel with evident inflammation and one suspects that sometimes in these cases the mesenteric vessels are occluded, in some cases by arterial emboli, in others thrombosis of the mesenteric veins resulting from ulceration in the inflamed segment of the gut, most commonly of course in acute appendicitis, the most frequent cause of portal embolism.

I would like to put on record two extreme cases in point, which occurred in 1901:

A young man of 35, on getting up from a chair, was suddenly seized with an extremely severe, agonizing pain in the chest. He was given morphine up to one Gr., without relief. He then received nitroglycerin 1/100, following which pain subsided temporarily. At 4:30 A. M. patient was seen by me; pulse 140; respiration 30; patient in great agitation; abdomen distended, moderately rigid; no sound of peristalsis. In an hour pulse had increased to 150. Leukocytes 27,000. 10 A. M. exploratory incision showed the entire midgut necrotic and flaccid. Patient expired about 1 P. M. Autopsy showed a small perforating ulcer, doubtless syphilitic, in the arch of the aorta, producing a dissecting aneurysm, the adventitia of the aorta being dissected off the muscular coat as far as the iliac veins. The mesenteric obstruction was complete, produced by the pressure of the blood between the adventitia and the muscularis.

Quite in contrast to this case was that of a banker, aged 53, with presumed gall-stone colic. His physician advised operation. Patient demurred, asked could not something else be done. The physician said, "Yes, you might go to Carlsbad." He went to Carlsbad and took the "Kur." He returned quite relieved. He had hardly reached home when he had another attack. A second visit to Carlsbad relieved him of his pain. A few months later he became suddenly distended, and had very acute pain. Operation showed a large part of the small intestine thickened, congested and cyanotic, a large amount of bloody serum free in the peritoneal cavity. The mesentery was ligated and the loops of small bowel hung out of the wound as in the Mikulicz technic, the patient being in such desperate condition that resection seemed contraindicated. He died the next day. Autopsy showed pancreatitis with fat necrosis which had encroached upon the mesenteric vein near its junction with the splenic so that the vein was no larger than the lead of a lead pencil, and this was obstructed by a small clot.

DR. ALTON OCHSNER (New Orleans, La.).—An insufficiently appreciated cause of mesenteric thrombosis of venous type is that associated with prolonged ingestion of alcohol. Doctor Storck, in our clinic, has had five cases occurring in young individuals in whom a venous mesenteric thrombosis had

occurred following prolonged imbibition of alcohol. In two of these, diagnosis was not made preoperatively, but in three the diagnosis was made. Prognosis in this type of case is good. The only fatal case we have had was a case in which we did resection. The other four cases were operated upon, but no resection performed. All recovered.

DR. FREDERIC W. BANCROFT (New York).—Doctor Douglas has presented a vivid picture of a severe and tragic catastrophe.

I was particularly interested in the cases presented where autopsies had been performed and there was no real vascular occlusion noted. I wonder if there may not be another explanation in addition to the one given by Doctor Douglas. In opening an abdomen through a small incision in the early exploration of an intestinal obstruction it is easy to liberate a band or to replace a volvulus without the operator being certain that he has done so, and it may be that in some of these cases there was an actual mechanical obstruction of the vessels. This mechanical cause may have been pressure on the vessels from without—and not occlusion from within by thromboses.

The percentage of correct preoperative diagnoses should be higher if our knowledge of the pathology is correct and we analyze our physical findings. After the thrombosis occurs the intestinal wall becomes edematous and swollen, with a lumen containing hemorrhagic fluid and very little gas. A flat roentgenogram taken at this time will show an abdomen with the intestines full of fluid, in contradistinction to the usual obstructive case where gas forms a large part of the intestinal contents. Physical examination will reveal a flat abdomen on percussion, and on auscultation no peristalsis can be detected. One has then the picture of a paralytic obstruction. Doctor Pound of the Fifth Avenue Hospital has made the positive diagnosis of thrombosis by the roentgenologic evidence presented in three cases. It is a principle in medicine that where there is a definite reaction of hyper- or hypoactivity, the opposite will be found: That is, we find cases of hyperthyroidism and hypothyroidism, of hyperacidity and hypoacidity, of hypertension and hypotension.

It is admitted generally in medicine that there are potential intravascular bleeders. This is noted particularly in thrombocytopenic purpura, in some of the leukemias, and also in obstructive jaundice. If this be true, there should be then cases which are potential clotters.

About seven years ago Dr. Stanley Brown and I started a study of the blood clotting elements of patients, both pre- and postoperative, to see whether we could determine by blood examinations if such patients might be liable for thromboses. Our first tests were very cumbersome and could not be carried out by a regular hospital clinic. However, through the aid and advice given us by Dr. Armand Quick, who worked for two years on full time on this problem, we have suggested a test which we believe is simple enough for any hospital and which we believe gives a fairly accurate account of the patients' clotting tendencies. In studying these cases we have found that sodium thiosulphate given intravenously, and a diet low in proteins and fats, is of distinct prophylactic benefit. As an example of repeated embolism I might cite a case which had been operated upon three times previously and following each one of these operations the patient had developed phlebitis associated with emboli. She was prepared for a fourth operation by a diet low in proteins and fats and with sodium thiosulphate and went through this procedure without any accident ensuing.

It is our opinion that a prophylactic regimen can be utilized which will diminish the percentage of this accident. We wish to emphasize, however, that we believe that trauma, slowing of the blood stream, dehydration and infection are the most important factors to be avoided.

RESULTS OF SPLENECTOMY IN CHILDHOOD

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INASMUCH as the vogue for splenectomy in various conditions is undoubtedly increasing, it seems worth while to discuss briefly the indications which one meets for this operation in childhood and the results which one can hope to achieve. In general, it may be said that these indications have all been arrived at empirically by trial of operation rather than from any previous definite knowledge of the etiology of the various conditions. The indications may be considered as falling into four separate categories, aside from the rare primary tumors which are occasionally encountered. These are:

- (1) To put a stop to a perverted pernicious activity of the spleen which may be designated hypersplenism.
- (2) To check the progress of some little understood pathologic changes in the splenohepatic circulatory apparatus.
- (3) To rid the body of an organ grossly enlarged and rendered useless by disease.
- (4) To remove a lurking place for certain types of infection.

Under some conditions more than one of these indications may be met by the same operation. We shall consider the application of these indications in the various classes of disorders in which the operation has been found useful.

Constitutional Hemolytic Anemias.—There are four diseases in this group which are of importance in childhood: hemolytic icterus; sickle-cell anemia; erythroblastic anemia and erythroblastosis of the new born. Splenectomy has been performed often in the first three of these disorders, only occasionally in the last.

Hemolytic Icterus.—This is a condition in which splenectomy has scored its greatest successes and in which it is usually regarded as the best method of handling the disorder and as being almost certain in its results. There is little occasion for comment on the disease itself, whose clinical picture is well enough known. There are some questions, however, regarding the most favorable time for operation and regarding the possibility of failures. As to the time of operation, it has been generally believed, in regard both to this disease and to other diseases in which there are crises of blood destruction, that it is unwise to operate during a crisis. We have followed this rule in our own clinic so far as possible, and on two occasions, to be spoken of later, when we have departed from it we have met with disaster. Recently Doan, Curtis and Wiseman have reported excellent results from operations

performed during the crisis, utilizing, of course, a very careful technic and having due regard to all possible risk. We still think, however, that this is so far as possible to be avoided, although we should feel encouraged by their paper to undertake the operation rather than submit the patient to the possible danger of going through a very severe crisis. In general we feel that it is better when, as often happens, we see the patient for the first time in the course of a crisis to wait until the crisis is over and the blood has come back to a fairly good level of red cells and hemoglobin before performing the operation.

Our records show six operations on children with this disorder which in all but one of the cases was definitely of the hereditary type. In the one exception there was a strong family heredity of pernicious anemia, but the child had a typical hemolytic icterus. In all of these cases, so far as we are able to ascertain at present, the operation has resulted in a complete cure of the primary condition. One of the patients has had, since her operation, some trouble from gallstones, a common complication, and recently has developed symptoms of duodenal ulcer. We have seen none of the recurrences of jaundice and anemia, which are occasionally reported, though we have been on the lookout for them, especially in cases where supernumerary spleens have been found and removed at the time of operation, as we have believed that the development of such a spleen would be a very likely cause for the return of symptoms in the occasional case.

Sickle-Cell Anemia.—This is another of the chronic hemolytic anemias of childhood which is accompanied by splenomegaly and which has, superficially, a very considerable resemblance to hemolytic icterus. The success of splenectomy in hemolytic icterus has led to a number of trials of the operation in this disease. There is, however, ample evidence that in sickle-cell anemia the disorder involves a greater part of the reticulo-endothelium than is involved in hemolytic icterus, in which from the results of splenectomy one might fairly conclude that the spleen is the organ which is almost entirely responsible for the blood destruction. We have not believed that in sickle-cell anemia one could expect a cure or any marked alleviation of the anemia. We have, however, performed the operation a number of times in the hope of relieving certain special symptoms.

Two of the troublesome symptoms in sickle-cell anemia are the crises of abdominal pain, which resemble quite strongly the crises of hemolytic icterus but are more often accompanied by definite splenic thrombosis; and recurrent attacks of pain in and around the joints which have never been satisfactorily explained. We have performed splenectomy on four cases of sickle-cell anemia in an effort to relieve some special symptom.

In the first case, the reason was the frequency of hemolytic crises accompanied by abdominal pain. This child has been observed over a period of some six years since the operation and while her anemia has not been particularly improved she has been practically entirely free from the crises and the pains.

In the second case, while there were rather marked abdominal crises the chief difficulty was with the joint pains. In this case, since the operation was performed about three and one-half years ago, the patient has been, according to her own and her parent's statement, entirely free from the joint pains, although here again there has been only very slight improvement in the anemia since the operation.

In our third case, the patient had, in addition to joint pains, periodic convulsive attacks of an epileptiform type of whose causation we did not feel perfectly certain, but inasmuch as cerebral accidents have been reported a number of times in patients with hemolytic icterus and sickle-cell anemia there seems to be reason to suppose that they are related to the disease process. In this case the boy, during the year's observation after splenectomy, has had no trouble with the exception of one mild attack of abdominal pain. Here again the course of the anemia itself is not perceptibly changed by the operation.

In the fourth case, the patient was operated upon shortly after an attack of splenic thrombosis, and an enormous spleen was removed of which nearly one-third was taken up by a large fresh infarct. The patient died in shock shortly after the operation but as an autopsy was not permitted we do not know whether this may not have been the result of hemorrhage from the vessel stump. It does not seem likely that it was the result of operation during a crisis, as the crisis apparently was over and the blood on the upgrade at the time of operation.

We have said that the course of the anemia has not seemed to be appreciably improved following the operation. This has been our impression so far as our own cases are concerned. In other clinics around the country the feeling seems to be that the patients do somewhat better when the spleen has been removed.

We have had some experimental indication of a possible reason for this. We have thought that an important factor in the pathogenesis of this disease must be a peculiar physiochemical structure of the red blood cells. In some studies of the lipid makeup of the cells in the hemolytic anemias we have found that in sickle-cell anemia the lipids are definitely abnormal before splenectomy but show a return toward normal after the organ has been removed. Whether we may find a similar thing to be true of the protein constituents of the cell we do not yet know.

Erythroblastic Anemia.—This is an essentially chronic anemia peculiar to children of the Mediterranean races which almost invariably results fatally within the first ten years of life. It is characterized by a gradually enlarged liver and spleen, marked marrow hyperplasia and a great number of imperfectly formed red cells in the blood stream. There is no reason to suppose that the spleen plays any important part in the causation of the condition and its enlargement is probably almost entirely secondary. The organ becomes so large, however, that it seems worthwhile to remove it simply to relieve the child of the burden of its great weight and the operation has

actually been performed in most of the reported cases. We believe the general experience has been the same as ours—that there is no particular change in the anemia after the operation with the exception of the appearance of a remarkable number of nucleated red blood cells which persist for a period of years after the splenectomy. We have felt so far as our own cases are concerned that the patients were more comfortable and lived somewhat longer after splenectomy than we should have expected without the operation. We have operated upon five patients. The operation is somewhat more difficult in this than in most other conditions for which it is performed because of the great size of the spleen and the number of adhesions. We believe, however, that it is worth doing.

Erythroblastosis Fetalis (Erythroblastosis of the Newborn).—This condition, which has attracted a good deal of recent interest, is really what

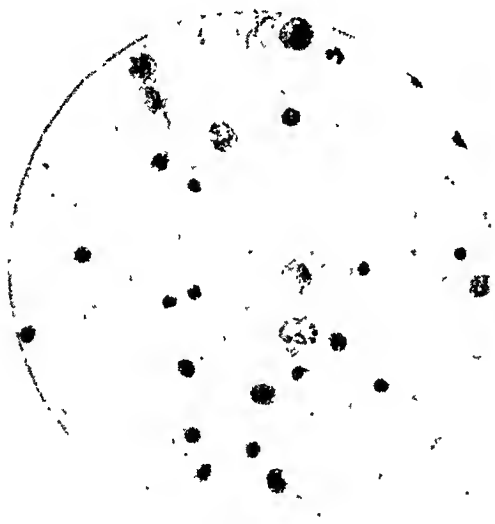


FIG. 1.—Blood smear showing nucleated erythrocytes.

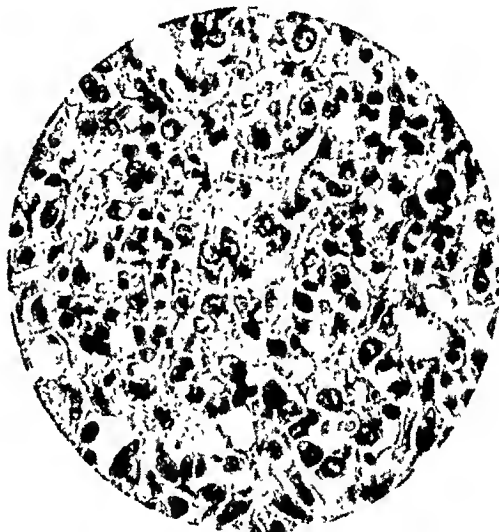


FIG. 2.—Liver—hematopoietic activity— islands of hematopoiesis scattered throughout the parenchyma.

was formerly known as familial icterus gravis neonatorum. It is a macrocytic hemolytic anemia attended by intense bilirubinemia and jaundice, developing either shortly before or just after birth. The familial element is important, as there are other types of severe jaundice occurring during the newborn period, especially those due to sepsis. The blood picture is characterized, in addition to the bilirubinemia, chiefly by a high percentage of nucleated erythrocytes (Fig. 1), most of which are normoblasts. The liver and spleen are enlarged, and on section these and other depots of reticulo-endothelium show many areas of extramedullary hemopoiesis (Fig. 2). The treatment most in vogue has been repeated transfusions, which have saved some of the reported cases.

Nothing is known as to the etiology of this disorder. Inasmuch as a large proportion of the cases terminate fatally within a short time, and as the character of the hemolysis seemed to us strongly suggestive of perverted splenic activity, we have been encouraged to make trial of splenectomy in the only

two cases in which we have had opportunity. As we were the first to do this, we summarize these cases briefly here.

CASE REPORTS

CASE I.—A boy, nine days old, of Irish parentage, was admitted to the Children's Hospital, November 26, 1931, because of grave anemia and intense jaundice. The history was of progressive anemia and jaundice beginning during the first day of life. There was a history of several siblings dying with jaundice during the newborn period, and a somewhat vague story of similar happenings in the mother's family.

Physical examination revealed nothing abnormal except the moderately enlarged liver and spleen, pallor and deep jaundice. The blood showed many macrocytes, about 3,000 normoblasts, and a few earlier nucleated forms. Hemoglobin was 3.4 Gm.; red blood cells, 1,080,000; white blood cells, 21,000; differential, normal. The icterus index was 300, and there was marked urobilinuria. A series of transfusions was given, with improvement in the general condition and some lessening of the jaundice. On December 1 the child was taken home because of the intervention of a physician friend of the family. Hemoglobin at that time was 11 Gm. On December 10 he was readmitted with the same picture: hemoglobin three Gm. and very deep jaundice. After a long series of transfusions and some intravenous liver extract with only transient benefit splenectomy was finally performed January 4. Hemoglobin at that time ten Gm.; red blood cells, 3,280,000; icteric index, 300. No transfusions were given after operation. The jaundice disappeared entirely after five days, the icterus index returned to normal within the same time, and the hemoglobin rose and remained between 11 and 12 Gm. Unfortunately the operation wound became infected and the baby died 16 days after the operation of peritonitis. There was no question in our minds that the operation had cured the primary condition.

CASE II.—Seen with Dr. Harry Berman at the Woman's Hospital. A girl baby, born January 14, 1935. Was noticed to be deeply jaundiced within the first 12 hours. She was the second child in the family, the first having died of jaundice when four days old. Physical examination was negative except for marked jaundice and enlarged spleen. She was given 65 cc. of blood 12 hours after birth and splenectomy was performed the following day. Before operation the blood showed: hemoglobin, 90 per cent; red blood cells, 4,250,000; marked macrocytosis and anisocytosis; marked polychromatophilia; numerous nucleated erythrocytes; icterus index, 300. No post-operative transfusions were given. The icterus index remained high for six days, being 260 January 21, but falling to five January 24, by which time the skin had regained its normal color. The hemoglobin reached 99 per cent January 18, remained at that level for several days, then followed the usual course of the blood of the newborn, declining gradually for a few weeks, then rising again. The baby is now a normal child.

The excised spleens in these two cases weighed 96 and 102 Gm., respectively. Both showed the typical pigment deposits and extramedullary hemopoiesis. There was no appearance of phagocytosis of erythrocytes. In both cases lues and sepsis, possible causes of similar conditions, were believed to have been excluded.

From our experience with these two cases, and knowledge of the success of a third splenectomy in the clinic of Doctor Clausen of Rochester, we think that the operation should have further trial in this disease. If it is to be adopted, we think it should be as early as possible, as death sometimes occurs within 24 hours of the appearance of the jaundice, and there seems to be no way of predicting whether in a given case this event may be averted by transfusion.

Hemorrhagic Disorders.—Of these there is one, purpura hemorrhagica, in which splenectomy is quite generally conceded to have been nearly as successful in properly selected cases as it is in hemolytic icterus. The proper

selection of cases must be emphasized. Purpura, associated with lack of platelets, occurs in a number of unrelated conditions. Typical essential thrombocytopenic purpura is an idiopathic, often hereditary condition. This is either chronic or recurrent in its nature. There is a very similar condition which is secondary, usually to infection, and which often at least occurs in only a single attack which is followed by complete and permanent disappearance of the symptoms. A third form is that which occurs in several types of disease of the bone marrow in which there is interference with platelet production rather than the destruction of the platelets by splenic hyperactivity which seems to be the underlying fault in the first two types. This latter type is seen particularly in aplastic anemia and in infiltrating disease of the marrow, such as the leukemias.

It is evident that splenectomy cannot be expected to help in the infiltrating diseases or in aplastic anemia and that there would be no good indication for it in secondary purpura in which there is good prospect that the first attack may be the patient's only one. It is, therefore, of course, important that careful differential diagnosis should be made and we believe that it is never wise to operate during a first attack unless it is peculiarly obstinate and long drawn out. We have found by experience that the greater proportion of the patients we see in first attacks of purpura never have a second attack. We have, consequently, out of a very considerable series of cases, found good indication for operation in only six. Of these all, so far as we know, have been permanently relieved. In one of them five supernumerary spleens were removed at the time of operation. This patient has returned once with a few purpuric spots and a slightly low platelet count. The condition was promptly relieved by treatment with snake venom. It is possible, however, that this boy is developing a supernumerary spleen and that later an exploratory operation may be necessary.

We have knowledge of one case, in another clinic, where a similar sequence of events was observed and at a secondary operation a well grown supernumerary spleen was removed. We have had one fatality in a case in which the operation was undertaken only as a last resort with no expectation of success. The patient, an infant one year old, had developed a very severe secondary thrombocytopenic purpura shortly after an attack of measles. In addition to the purpura there was extensive suppurative cervical adenitis. The case was not considered a suitable one for operation, which was performed only when all other methods, including several transfusions, had failed to check the bleeding. The baby was almost moribund at the time of operation, and died within a few hours.

Splenic Anemia and Splenomegaly with Gastric Hemorrhage.—Splenic anemia may be said to be the waste basket diagnosis of pediatric hematology. There is a considerable number of conditions in which one may meet with an enlarged spleen and anemia which are quite difficult to classify. Some of them are due to such specific infections as syphilis, malaria, tuberculosis and undulant fever. These, of course, should be carefully ruled out. It is rather

common to consider those in which there is no such obvious cause as belonging in the rather vague classification of Banti's disease, which is hardly thought of nowadays as more than a syndrome. There is, however, one fairly definite type in which there is marked splenomegaly and leukopenia without obvious cause which often at least goes on to the later stages of the Banti syndrome-bleeding from gastric or esophageal varices and ultimate cirrhosis of the liver, in which it is generally believed that favorable results are to be had from early splenectomy. Some observers think that this type should be definitely separated from the miscellaneous group of cases with splenomegaly, due to infection, and without the characteristic leukopenic blood picture. The disease which is spoken of as splenomegaly with gastric hemorrhage differs from this type of splenic anemia chiefly in the fact that the hemorrhages are an early rather than a late symptom in the disease. It is quite possible that both are due to disease of the splenic vessels. Although it has not been possible to demonstrate this in many of the cases at the time of splenectomy it is believed by many pathologists that in the Banti syndrome and possibly in the second syndrome the original trouble does lie in a thrombophlebitis of the splenic veins. Reports of the results of the operation in this syndrome of splenomegaly with early gastric hemorrhage have not been invariably good but a large percentage of the patients have been at least markedly improved and some apparently cured.

We have had six operations for various types of splenomegaly with anemia in only two of which did the condition correspond to the typical splenic anemia with leukopenia. Both of these were definitely benefited by operation and are now doing well. In three others in which the splenomegaly was associated with leukocytosis rather than leukopenia and the condition was probably due to chronic infection, the results of splenectomy have not been especially good. One of the patients has since died; two others have not been particularly benefited. We have had only one case of the type with early gastric hemorrhage. This boy was operated upon one and one-half years ago and has had one very slight bleeding attack since.

With the exception of the cases with erythroblastic anemia we have had no operations for the purpose merely of relieving the patient of the weight of the enlarged spleen of which we have spoken. This indication may occur in leukemia, in Gaucher's disease and in some other types of extreme splenic enlargement, and we think that removal is a perfectly legitimate thing to do provided it is understood that it can give no real relief for the disease process. We have not had occasion to operate for the removal of the spleen as a focus of infection. This might happen in malaria, syphilis, tuberculosis or undulant fever and we have once or twice considered it seriously. We should be definitely inclined to operate under the proper conditions.

SUMMARY

The indications for splenectomy, which is having a constantly increasing vogue, are arrived at chiefly empirically, by trial of the operation, as the

fundamental etiologic factors of the conditions in which it may be of service are not well understood.

In general, the reasons for performance of splenectomy fall into four categories:

(1) To put a stop to a perverted, pernicious activity of the spleen, conveniently designated "hypersplenism" (hemolytic icterus, purpura hemorrhagica, erythroblastosis fetalis, sickle-cell anemia).

(2) To check the progress of pathologic changes in the splenohepatic circulatory system (splenic anemia, splenomegaly with early gastric hemorrhage).

(3) To rid the body of the burden of an organ grossly enlarged and rendered useless by disease (erythroblastic anemia, leukemia, Gaucher's disease).

(4) To remove a lurking place for certain types of chronic infection (lues, malaria, undulant fever, tuberculosis).

Results are reported of 29 splenectomies performed upon children. Of these six were for hemolytic icterus; four for sickle-cell anemia; five for erythroblastic anemia; two for erythroblastosis fetalis; six for purpura hemorrhagica; and five for different types of "splenic anemia."

Hemolytic Icterus.—This is the condition in which splenectomy has scored its greatest success. All of our patients seem to have recovered completely from the primary disorder, with no signs of recurrence. One has had trouble from postoperative adhesions and duodenal ulcer. We have avoided operating during the hemoclastic crises.

Sickle-Cell Anemia.—The rôle of the spleen in the pathogenesis of this disorder is not clear. In our cases the anemia has been little benefited by the operation, but the abdominal and joint crises have been alleviated, and in one case epileptiform attacks ceased after the splenectomy.

Erythroblastic Anemia.—Splenectomy in this disease has not appreciably altered the course of the anemia. It is followed by a remarkable, permanent increase in circulating normoblasts. The patients are considerably relieved by freedom from the weight of the greatly enlarged spleen, and may live somewhat longer.

Erythroblastosis Fetalis.—In our two cases, and in one of which we have knowledge in another clinic, splenectomy promptly checked the rapidly progressing hemolytic anemia. Considering the gravity of the condition we believe that the operation should be performed as soon as the diagnosis is made.

Purpura Hemorrhagica.—Results here are nearly as good as in hemolytic icterus. So far as possible, unless the thrombocytopenia is obstinate, we avoid operating after a single bleeding episode, as the majority of the cases are of the secondary type, and recover spontaneously. Of the six patients operated upon, four recovered completely, one has had a single slight recurrence, and one, operated upon during a very severe bleeding episode, died.

Here, as in hemolytic icterus, we avoid operating during crises, except as a last resort.

Splenic Anemia.—Two patients, exhibiting the syndrome with splenomegaly, leukopenia and anemia often called the first stage of Banti's disease, seem to have been cured by splenectomy. Of three, having splenomegaly and anemia without the characteristic leukopenia, apparently secondary to infection, one has died, and two have gone on to the late stages of the Banti syndrome with hemorrhage and cirrhosis.

We have had one case of the condition with splenomegaly and early gastric hemorrhage, which was relieved but not completely cured by operation.

We have had no occasion to operate for chronic leukemia or Gaucher's disease, or to remove a focus of chronic infection, though we believe that the operation may be indicated for any one of these conditions.

We have not formed definite conclusions regarding recent proposals to remove the spleen for hypoplastic or early aplastic anemia.

Whenever a recurrence of trouble appears after an apparently successful splenectomy we think that consideration should be given to the possibility of the development of an accessory spleen.

DISCUSSION.—DR. EDWIN MILLER (Chicago, Ill.).—My experience with splenectomy has been limited to cases of essential thrombocytopenic purpura. Since Werlhoff first described this interesting disease almost 150 years ago, there has been a progressive development in the literature on this subject, and a great part in this development has been taken by Doctor Whipple. There is no question in this disease but that the effect of splenectomy in the majority of cases is as dramatic as anything one sees in surgery.

The case which I have to present is that of a young girl 11 years of age who has been studied at the County Hospital by Doctor Poncher of the Research Department of the University of Illinois, and myself, since 1929, when she presented a typical clinical picture of a very severe case of thrombocytopenic purpura, characterized, as you all know, by spontaneous hemorrhages, by a prolonged bleeding time, normal clotting time (but failure of retraction of the clot), and a very low platelet count. It was obvious, in spite of several blood transfusions with some slight improvement in this girl's condition that splenectomy was definitely indicated.

Almost immediately after splenectomy the condition in this girl improved dramatically. The bleeding time returned very quickly to normal, the clotting time remained normal, and retraction of the clot took place in fairly normal time, the platelet count very rapidly returned to above the normal level, and the tourniquet test became negative. All these signs of improvement have continued since that time, a period of six years ago. We have carefully studied the patient since this time.

We have found since the onset of her menstrual period that she has continued to have no tendency whatever toward any spontaneous bleeding. She has developed normally, gone to school, received all kinds of accidents in play, and there has never been any tendency either in that way or at the time of her menstrual periods for any spontaneous form of hemorrhage, so we feel that the case illustrates the typical good result which we all recognize will follow in a large per cent of those cases of thrombocytopenic purpura which have very accurately been diagnosed before operation.

DR. W. J. MERLE SCOTT (Rochester, N. Y.).—I want to mention only one group of cases that Doctor Penberthy has spoken of because this, as far as I know, is a new indication for splenectomy occurring in literature. This is the group of erythroblastoses of the newborn or the group that is more commonly known in pediatrics as icterus gravis.

Newborn babies, of course, have a physiologic icterus very frequently. The differentiation between physiologic icterus and icterus gravis is as a rule easily made. The icterus, in the first place, appears earlier in icterus gravis than in icterus of the newborn. It appears within 48 hours, usually 24 hours. Of course, it is a much more intensive jaundice, the icteric index being usually between 250 and 300, as in the cases reported here.

We had heard of Doctor Cooley's discussion of one such patient in a pediatric meeting and were encouraged to carry out splenectomy for a typical case of icterus gravis or erythroblastosis fetalis. The mother had already had siblings that died. One brother had died and another had had a very severe icterus which had left him with a condition that frequently follows when they do recover, namely, a profound injury to the brain from the staining with blood pigment that occurs.

We felt we had very little to lose in this child by carrying out splenectomy. It was interesting how, in spite of the very intense jaundice that existed, there was no tendency whatever toward bleeding.

I want to emphasize their recommendation, that in this condition, which has a very high mortality and bad prognosis, it would be well worth while to carry out splenectomy early.

DR. JAMES M. HITZROT (New York, N. Y.).—I would like to report the results of a group of cases of erythroblastic anemia which have been reported before (ANNALS OF SURGERY, vol. 88, 1928).

The oldest one, a girl, reported by Stillman (Am. Jour. Med. Sc., vol. 153, 1917) and subsequently by myself, lived for 18 years after a splenectomy, continuing to have the increase in the nucleated reds throughout that period. She went through a number of critical illnesses and finally died of acute pneumonia. Of the other three children from the same family which were reported with this disease, one died of acute mastoid within nine months after the operation. The other boy lived to be 17. He was operated on when he was six. He lived to be 17, with a continued picture of erythroblastic anemia. He grew, went through puberty without any trouble, and died also of an acute condition, probably pneumonia. He was not cured at all although he continued to grow.

The girl in the same family died six years after the splenectomy, presenting the same blood picture, apparently of influenzal pneumonia. I do not know definitely what caused the death of the above two cases as I did not see them but they were reported to me as stated above. The first case is the one that lived the longest and is the oldest in this series so far as Doctor Stillman has been able to find. She was very interesting to us because she was one of the earliest cases and one of the cases that we suspected for the first time as being a curious disease because of the enormous shower of nucleated reds which appeared right after splenectomy.

I would also like to report on another case of an essential purpura previously reported (ANNALS OF SURGERY, 1923) who has now lived a little over 12 years. She has gone through pregnancy and went through her menstruation without any difficulties whatsoever, and no unusual bleeding. Her blood picture at this time is reported as perfectly normal.

DR. GEORGE J. HEUER (New York, N. Y.).—I am interested to know if use has been made of a technical procedure in splenectomy which we have employed in several instances. It is well known that if you give adrenalin to a patient with an enlarged spleen, you can demonstrate very easily the considerable shrinkage of the spleen, and if you make blood studies before and after the injection of adrenalin you can demonstrate that the patient with an enlarged spleen may sometimes autotransfuse himself to the extent of 250 cc. of blood.

We have utilized this fact at the operating table, giving the patient an average dose of adrenalin after the abdominal incision had been made and the spleen exposed. We have found it technically, in some cases, much easier to manipulate a shrunken spleen, that has become sort of leathery and tough, than the previously much larger and more friable organ.

One must be sure the adrenalin is active. Recently in a case of enlarged spleen an injection of adrenalin failed to cause shrinkage of the spleen. The adrenalin was tested in the laboratory and found to be inert.

IDIOPATHIC ULCERATIVE COLITIS

A REVIEW OF 149 CASES

WITH PARTICULAR REFERENCE TO THE VALUE OF, AND INDICATIONS
FOR SURGICAL TREATMENT

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WE ARE referring to the so called chronic idiopathic ulcerative colitis, excluding, as far as possible, cases of amebic dysentery, tuberculous colitis and bacillary dysentery. It is a diffuse process usually beginning in the rectum (95 per cent of Barger and Mayo's¹ 1,500 cases) and frequently involving the entire colon to the ileocecal valve. Rarely (1.3 per cent of our cases) does it extend into the terminal ileum. It is segmental in rare instances, or may involve only the rectum or a portion of the left colon.

We are not concerned at this time with the etiology of the disease or the relative merits of specific versus non-specific treatment. We, as surgeons, are asked to make important decisions in a group of desperately sick patients. As far as we can tell from our own experience and from the literature, these same decisions must be made whether the disease is infectious or otherwise, and whether specific or non-specific medical treatment is employed.

During the past four years it has been our responsibility to meet any surgical problems that might arise in the cases admitted to the wards at the Massachusetts General Hospital. The number of cases so seen has not been large, but the problems presented have been of the greatest importance, in most instances involving a question of life and death. The relative infrequency with which the decisions have had to be made, the extraordinary variations in the disease, and the resulting difficulty in establishing definite criteria from which to make such decisions have suggested a critical review of the cases at this hospital, with particular reference to those aspects of the disease which pertain to the value of, and indications for, surgical interference.

One hundred forty-nine cases in which a diagnosis of ulcerative colitis seemed definite, according to our present criteria, have been admitted to the wards of the Massachusetts General Hospital during the 20 years prior to January, 1935. During the first decade most of the cases were loosely classed as tuberculosis, many were admitted to the surgical wards and, except in very mild cases, an appendicostomy or cecostomy for purposes of irrigation was advised. During the past ten years the patients have been admitted to the medical wards to be carefully and completely studied in an attempt to exclude tuberculosis, amebiasis, and bacillary dysentery. During this period each case

not responding to medical treatment has been seen in consultation by a surgeon, and if operation was advised has been transferred to the surgical service. The operation of choice has been an ileostomy with complete external diversion of the fecal stream, except in a few cases where the disease was localized and a more distal procedure could be carried out.

Symptoms.—The variations in the symptomatology have resulted in occasional uncertainty as to diagnosis, particularly in the more acute cases. The following points from the histories are of interest.

Blood.—Rectal bleeding is an almost constant symptom. It is described most frequently as "streaks of blood" and was noticed by 87 per cent of the patients in this series. Massive hemorrhage—a symptom of serious importance—is fortunately rare, being found in only 5 per cent of our cases. On the other hand, one of our fatal cases had a profuse diarrhea without gross blood, but with large ulcerations visible through the proctoscope and demonstrated throughout the colon at postmortem examination.

Diarrhea.—This occurs frequently without blood at the onset, and is present in all cases at some stage of the disease. *Constipation* is not uncommon, particularly prior to the onset of acute symptoms; in fact, in the occasional case obstinate constipation necessitating drastic catharsis has been given as the precipitating cause of the protracted diarrhea for which the patient sought relief. Blood and constipation may be associated just as may blood and diarrhea. In one case constipation, alternating with short periods of diarrhea, was present. The patient finally came to the hospital because of bleeding and failure to have a movement for five days.

Onset.—This may be sudden or gradual. One of our patients—a powerful young Harvard athlete—was seized with sudden dizziness and weakness while rowing, followed later by a bloody diarrhea and a temperature of 103°. In other cases, a sudden chill and high fever initiate the attack with an abruptness comparable to that in lobar pneumonia.

Recurring attacks of fever, marked prostration, rapid loss of weight and strength, with a natural tendency to remissions and relapses are characteristic of the disease. The frequency of recurrence varies. In one of our cases there were five admissions in a year. The longest period between attacks was 12 years. As in the cases studied by Banks and Borgen,² acute respiratory infections and emotional upsets were the most common precipitating causes.

Complications are common and at times serious. Peri-anal infections, skin lesions which may be acne-like, or diagnosed as erythema nodosum or erythema multiforme; multiple joint pains and swelling, keratitis, iritis and corneal ulcers have been encountered in this series. Of most significance, however, have been those symptoms referable to lack of vitamins; polyneuritis (in one of our cases resulting in temporary paralysis of lower extremities and inability to walk), skin changes, smooth tongue and tachycardia. Polyposis as it occurred in this series was not a true polyposis but rather a hypertrophy of remaining islands of mucosa following large irregular areas of complete destruction of the mucous membrane and later scar formation

(Fig. 1). Cancerous degeneration, occurring in 2.5 per cent of 800 cases, reported by Barga³ has not been found in this series.

Physical examination is of importance chiefly because of its negative character except for occasional tenderness along the course of the colon and those conditions secondary to the disease such as varying degrees of emaciation and pallor. The most interesting finding was the presence of a palpable spleen in 3 per cent of the cases.

Laboratory examinations are of importance primarily in excluding other

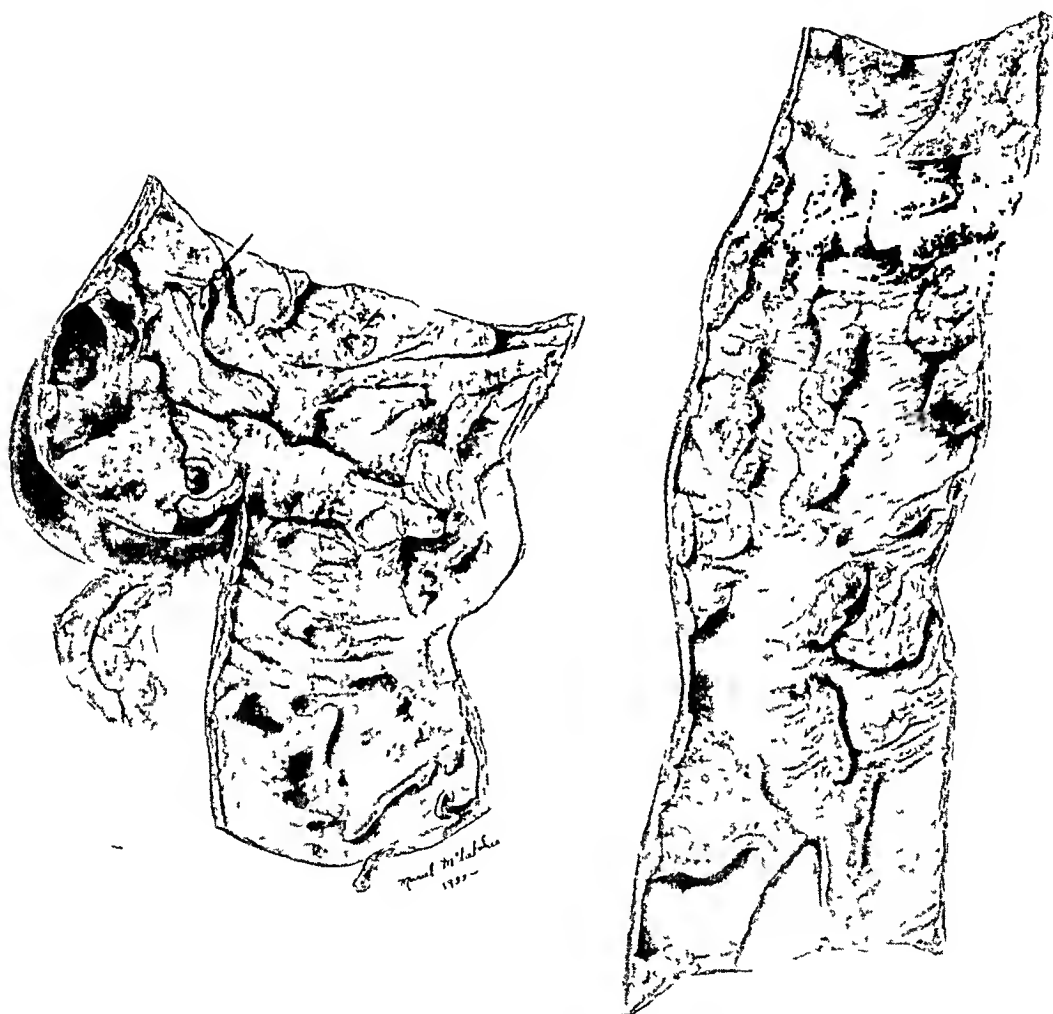


FIG 1—Section of the cecum with terminal ileum and of sigmoid from the fatal case dying of a general peritonitis secondary to perforation of the ileum. In this case about 22 cm of terminal ileum were involved. This specimen shows well the extensive loss of mucous membrane and resulting pseudopolyposis.

conditions such as amebiasis, bacillary dysentery, tuberculous colitis, and in estimating the degree of anemia or changes which have taken place in body chemistry.

Proctoscopy represents the most important single method of examination. Positive findings were present in all of the cases in this series. The appearance of the mucous membrane varies with the stage or manifestations of the individual case. The mucosa may be covered with a grayish mucopurulent

film which when gently wiped leaves a dark red granular bleeding surface. The outstanding characteristic is the diffuseness of the process. The red granular edematous mucous membrane, bleeding easily on slight trauma, may be studded with small white dots which represent small miliary abscesses in the mucosa, later breaking down to form the small superficial ulcerations of a later stage. These ulcerations may be small and seen with great difficulty or they may reach one or two centimeters in diameter, coalescing with adjoining ulcers, leaving large areas entirely without mucosa, with islands of edematous dirty red mucous membrane (Fig. 1), giving the appearance of multiple polypi. The valves are involved in the process and later may be scarcely perceptible in the late, rigid, narrow, tube like rectum. These findings are in contrast to the characteristic picture in amebic dysentery where small, superficial, slightly elevated ulcerations are found scattered in an otherwise normal appearing mucosa. From a tuberculous colitis the differential diagnosis by proctoscope alone may be more difficult. According to Martin,⁴ diffuse tuberculous colitis with ulcerations visible through the proctoscope is very rare except in a patient bedridden from tuberculosis. The tuberculous process advances from the ileocecal region downwards and through the proctoscope the ulcerations vary from a few millimeters to several centimeters in diameter with irregular outline. The intervening mucosa, slightly reddened, may be differentiated from ulcerative colitis with difficulty by one less experienced. Martin lays great stress on the fact that rarely does one find the diffuse contractions of the bowel and diminution in size of rectal valves in tuberculosis that is frequently seen in ulcerative colitis.

Roentgenographic examination by barium enema is next to proctoscopy our most valuable aid. There is early a loss of haustral markings, spasticity, rapid emptying, with the sawtooth serrations due to existing ulcers and later the characteristic contracted, stiff leadpipe appearance, not infrequently with one or more strictures.

The *diagnosis* is suspected in cases of bloody diarrhea with positive proctoscopic and roentgenologic findings, and is accepted when careful hospital study, including serologic and bacteriologic studies exclude tuberculosis, amebiasis, and bacillary dysentery as probable causes. In more recent cases an unsuccessful course of emetine or yatren may be given as additional evidence against an amebic infection. A negative roentgenogram of the chest is accepted as excluding a diffuse ulcerative colitis from tuberculosis. On the other hand, tuberculosis of the lungs may occur in association with a chronic idiopathic ulcerative colitis, as shown by pathologic and bacteriologic study of the diseased colon.

FATAL CASES.—Of the 149 cases in our series there have been 27 deaths, a hospital mortality of 18 per cent. Twenty or 74 per cent of the deaths followed some type of operative procedure.

Causes of Death.—Of 27 deaths in this series, 18 patients came to necropsy. Of these 18 cases, 13 had some type of operation and five died without operative interference (Table I).

TABLE I

Causes of Death in 18 Cases Examined Postmortem

Without operation	Number
General peritonitis from perforation of colon.....	3
Widespread sepsis.....	1
Extensive local disease—pneumonia.....	1
After operation	
General peritonitis from perforation of colon.....	3*
General peritonitis from perforation of ileum.....	1†
General peritonitis from opening of appendix stump after ileostomy and appendectomy.....	1
General peritonitis without obvious cause.....	4
Extensive local disease—pneumonia with abscess formation.....	1,
Bronehopneumonia.....	1
Abscess of lungs.....	1
Pulmonary edema—fatty degeneration of liver, pulmonary tuberculosis(?), intestinal obstruction.....	1
	—
	18

* In all three cases perforation occurred before operation.

† Twenty-two cm. distal ileum involved at time of operation; perforation through diseased bowel after operation.

Six of the 12 deaths from peritonitis were due to perforation of the bowel. It is interesting that as far as one could tell from the clinical records there was little evidence to suggest the exact time at which perforation had occurred. It is also of interest that in four of the cases death had occurred without extension of the disease to the ascending colon and cecum.

Records of fatal cases were gone over carefully in the hope of being able to segregate the group in which death was most apt to occur.

Age seems to be important. Ulcerative colitis is a disease of childhood through early middle life, 88 per cent of our cases occurring in patients under 50 years of age. The hospital mortality in this group was 13.7 per cent, as contrasted with 41 per cent in the group 50 years of age and over.

The number of attacks seems to have no great bearing on the seriousness of the individual relapse. In the two cases with longest intervals between attacks—12 and nine years—the second attack of each proved to be of the acute fulminating type with death from perforation within six weeks of the onset of symptoms.

Continued septic fever, rising pulse, abdominal pain, increasing abdominal tenderness or distension, massive hemorrhage, nausea, vomiting or inability to eat, are serious symptoms and were present singly or in combination in the fatal cases.

TREATMENT.—*Medical Treatment.*—Whereas formerly patients were admitted to and treated on either medical or surgical wards, all patients are now treated on the medical wards. The basic principles of treatment are: (1) rest, (2) high vitamin, high caloric, low residue diet; (3) eradication of focal

infection; (4) adjustment of social and psychiatric problems; (5) multiple transfusions. These form an integral part of the management of all the seriously ill patients whether or not operation becomes necessary. We have seen no ill effects from properly given transfusions as feared by Emery and Wasika.⁵ The largest number given to one patient during a single entry was seven. This patient survived an ileostomy and later a total colectomy; (6) irrigations; a variety of solutions have been used for irrigating the diseased colon, either through an appendicostomy or per rectum. Dilute silver nitrate, dilute solutions of potassium permanganate, acriflavin and Dakin's solution have all been in favor over varying periods of time. No one has any real claim to superiority over any other. We are unable to convince ourselves that irrigations of any type are of value and believe they may be harmful in the more acute cases. The one local procedure which has been used over a period of years is the gentle installation of warm starch solution into the rectum. This seems to give enough temporary relief to the badly irritated rectum to justify its use; (7) autogenous vaccines and ulcerative colitis anti-streptococcus serum have been used on a few patients but are not an integral part of the treatment; (8) emetine hydrochloride and yatren may be used on occasion as additional evidence for or against an amebic infection.

SURGICAL TREATMENT.—The surgical procedures used in an attempt to help control the disease are noted in Table II.

TABLE II
Operations Employed in 140 Cases of Ulcerative Colitis

Operation	Number	Deaths	Mortality Per Cent
Appendicostomy.....	4	2	50
Cecostomy.....	2	0	0
Colostomy.....	4	2	50
Resection and anastomosis.....	1	0	0
Ileostomy.....	54	15	35
Colectomy:			
subtotal..... 8			
total 2	10	1	10
Miscellaneous.....	22	2	9

There is nothing in a study of the above cases to alter our belief that the only operation which is indicated in ulcerative colitis is one which will give complete rest to the affected bowel by external diversion of the fecal stream proximal to the disease; and with few exceptions this means ileostomy. Failing this the only other recourse is extirpation of the colon.

Incidence of and Immediate Results after Ileostomy.—Although 54 or 36 per cent of the 149 patients have had ileostomies, the incidence of 41 per cent which has occurred in the past ten years probably more nearly represents the proportion of hospital patients who ultimately are operated upon. Ileostomy is not a curative procedure but the striking drop in temperature and pulse (Chart I) and the general improvement of the patient suggest the value

of complete rest to the badly diseased bowel. Unfortunately, the improvement is not always so striking as suggested in the accompanying chart. A rapid fall of temperature by crisis or lysis is sufficiently common, however, to leave little doubt in our minds as to the value of an ileostomy as a life-saving procedure.

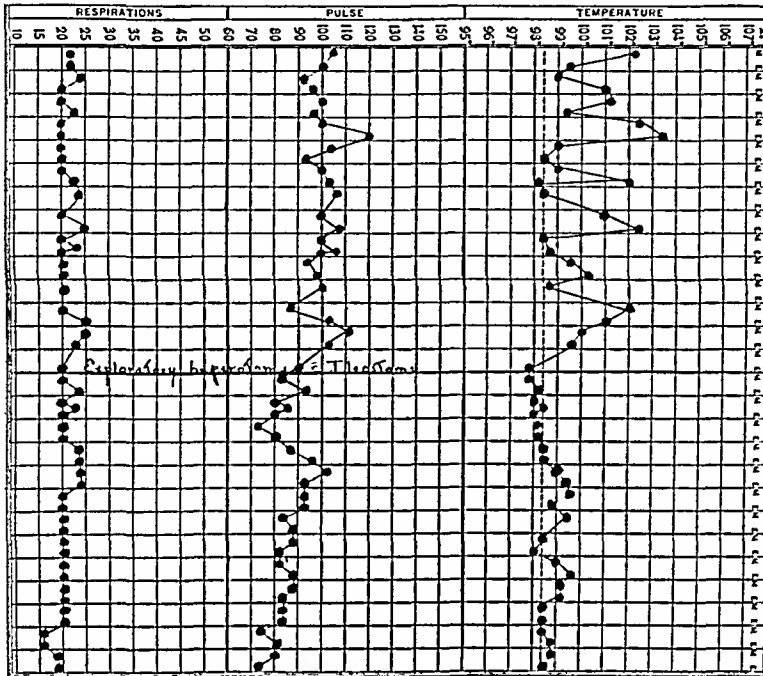


CHART I.—Shows striking drop in temperature immediately following ileostomy. This patient remained well for five years; later requiring subtotal colectomy for repeated hemorrhages.

We look upon ileostomy as a permanent condition. Rarely if ever under our present regimen will a badly diseased colon become free from disease after ileostomy. Should healing take place, multiple strictures and contractions will result making subsequent function impossible. Rather do we look upon ileostomy as the first stage of a removal of the diseased bowel in what will eventually probably be a high proportion of cases.

Mortality Rate and Causes of Death after Ileostomy.—Fifteen or 35 per cent of the 54 patients died. Decisions were made and operations done by 13 different surgeons. The benefits to the patient of the concentration of the more unusual and difficult problems to a small group of men is shown in Table III.

TABLE III

Mortality Rates Following Ileostomy According to Number of Operators

	No. operations	Deaths	Mortality per cent
Group I (2 operators).....	20	3	15
Group II (11 operators).....	34	12	35

A study of the fatal cases after operation fails to show specific reasons for the variation in mortality between the two groups.

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TABLE IV

Causes of Death after Ileostomy

Group I (2 operators)	General peritonitis from	
	perforation of colon (autopsy).....	1
	perforation of diseased ileum (autopsy).....	1
	Progression of disease (autopsy).....	1
Group II (11 operators)	General peritonitis from	
	open appendix stump (autopsy).....	1
	no obvious cause (autopsy).....	3
	Bronchopneumonia (autopsy).....	1
	Abcess of lungs (autopsy).....	1
	Acute fulminating attack (no autopsy).....	1
	Cause undetermined (no autopsy).....	4
	Massive hemorrhage (no autopsy).....	1

From the records one finds that in Group I the patient dying of "progressive disease" had been erroneously diagnosed as cancer and an exploration done. In Group II all except two patients had an exploration under general or spinal anesthesia and in five cases the appendix was removed at the time the ileostomy was done. The patient dying of general peritonitis secondary to an open appendix stump seems to us to be of sufficient significance to report in detail.

CASE REPORT

A boy of 16 was discharged from the medical wards July 22, 1933, 29 days after admission, for what was taken to be a mild ulcerative colitis. Two days after returning home he suddenly felt sick, vomited, had abdominal pain and movements every two hours. He lost ten pounds in five days. He was acutely ill on admission, vomiting and having almost constant bloody movements. With no improvement in 48 hours an ileostomy was advised and done under novocaine infiltration. An edematous fibrin covered appendix presented in the wound, the cecum was red, edematous, and there was a small amount of clear fluid. The operator was fearful of leaving the appendix and removed it, burying the stump with a fine catgut suture. An ileostomy was done. The immediate response to operation was fairly satisfactory except that he had more abdominal discomfort than usual. Six days after operation there was a marked increase in pain, with vomiting, elevation of temperature and death three days later. At autopsy there was a general peritonitis, the stump of the appendix being wide open.

From our own experience and from a study of fatal cases we believe that, except for those patients done for mechanical reasons, the following conclusions seem justified:

- (1) Novocaine locally is the anesthetic of choice.
- (2) Exploration is dangerous and contributes little if anything to the subsequent care of the patient.
- (3) A colon so diseased that ileostomy is indicated is too diseased to make appendectomy safe.

Indications for Ileostomy.—Technical Considerations.—Bargen, Brown and Rankin⁶ have given the following mechanical indications for ileostomy:

- (1) Polyposis with or without carcinomatous degeneration.
- (2) Strictures.
- (3) Incontinent anus.

In addition to these indications we believe that ileostomy has a definite place: (1) as a life-saving procedure, and (2) as a means *per se* or preliminary to subtotal colectomy, of changing a person from a condition of chronic invalidism to one of comparative physical well being and economic usefulness. We do not underestimate the inconvenience of an ileostomy, but we know no better criteria of the seriousness and discomforts of the disease than acceptance of ileostomy by the patient who has known these and feels compensated by the relief which ileostomy has given.

It is easy to say that an indication for ileostomy is the fact that adequate medical treatment has failed. The irregular course of the disease, its tendency to remissions, the insidious manner in which perforation may occur on the one hand, and the desire to do everything possible to avoid an ileostomy on the other, all tend to make the final decision one of the most difficult in medicine or surgery. Of one thing we are certain: absence of definite indications that medical treatment has failed is frequently responsible for "waiting another 24 hours for signs of improvement," possibly finding some indication that such has occurred, then delaying another day only to realize that the time has passed when ileostomy would be of avail.

While certain symptoms and signs are of more significance than others, it is impossible to give any definite criteria which will permit one to say that medical treatment has failed and ileostomy should be done. Those we believe to be of greatest importance in reaching this decision are:

- (1) Massive hemorrhage which usually denotes large and deep ulcerations, and in itself may be an indication for early operation.

- (2) Persistent fever especially if accompanied by a rising pulse.

- (3) Nausea, vomiting or inability to eat, particularly if associated with a serum protein below 5.5 per cent.

- (4) Abdominal pain, increasing distention or tenderness along the course of the colon.

- (5) Continued bloody diarrhea with secondary anemia when the patient's general condition, red blood count and hemoglobin are maintained, but not definitely improved by four transfusions of 500 or 600 cc. of blood at four to seven day intervals.

Any of the above symptoms in a patient over 50 years of age is more serious than in younger patients, and earlier operation is indicated.

In making final decision one must recognize that ileostomy is not curative, and while striking improvement may result from rest of the diseased colon, the patient must still have sufficient reserve strength to withstand the operative procedure and immediate postoperative discomforts.

Technical Considerations.—Rankin⁶ prefers an end ileostomy and describes an excellent technic. It has been our experience that in those cases where operation is done as a life-saving procedure the condition of the patient and the limitations of novocaine anesthesia will not permit closure of the right

gutter. The simplest procedure is a loop ileostomy, drawing a loop of ileum eight to ten inches from the ileocecal valve through a small right rectus or McBurney incision; a strip of fascia and skin are sutured underneath the bowel, as described by Jones⁷ for a colostomy. We have also used the end ileostomy dividing the ileum about eight inches above the ileocecal valve, inverting the distal end and dropping it back into the abdomen without obliterating the space between the bowel and lateral abdominal wall. We are not entirely satisfied with the results. There is a tendency, particularly of the loop ileostomy, to prolapse requiring a secondary operation in 20 per cent of our cases. If, on the other hand, the wound is closed too tightly around the bowel, obstructive symptoms will develop which, though not marked, may be of serious consequence to a patient already critically ill and badly in need of food.

COLECTOMY.—Of the 29 patients surviving ileostomy in the past ten years, ten have had a total or subtotal colectomy at this hospital and two elsewhere. There has been one death in our series, a patient who after a short period of improvement following ileostomy had a recurrence of symptoms, temperature and bloody discharge. A late and unsuccessful attempt was made to remove the colon in the hope of saving her life.

INDICATIONS.—The indications for colectomy are more definite than those for ileostomy and are

- (1) Polyposis with or without carcinomatous degeneration.
- (2) Recurring attacks of bleeding, temperature and malaise after ileostomy, frequently associated with multiple skin infections and joint symptoms.
- (3) Continued anemia and failure to gain in strength and weight, without other demonstrable cause.

If possible, the interval between ileostomy and colectomy should be at least four months to permit the small bowel to assume some of the functions of the colon and to get the patient into better general condition (Table V).

TABLE V
Indications for Colectomy and Interval Between Ileostomy and Colectomy

Interval	Indication	Result
49 mos.	Attacks of bleeding.	Relieved
24 mos.	Rectal bleeding. Painful joints.	Relieved
38 mos.	Protracted relapse with fever. Bleeding. Failure to gain after 4 transfusions.	Relieved
19 mos.	Continued rectal movements. Multiple skin infections. Corneal ulcer. Toxic arthritis. Acute iritis.	Relieved

TABLE V—*Continued*

Interval	Indication	Result
8 mos.	Continued symptoms. Blood. Lack of strength. Frequent vomiting.	Relieved
8 mos.	Continued loss of blood. Secondary anemia.	Relieved
5 mos.	Frequent bloody rectal movements. Toxic arthritis (knees). Entered hospital with fever. Strength not regained.	Relieved
8 mos.	Attacks of bleeding. Strength not regained. No weight gain. Continued secondary anemia.	Relieved
9 mos.	Continued bleeding with fever. Deficiency symptoms.	Relieved
2 mos.	Progressive failure. Marked anemia. Low serum protein.	Died

Technical Considerations.—The technical details of total and subtotal colectomy have been well described by Rankin,⁸ and Coffey.⁹ Total colectomy is a three stage procedure: (1) ileostomy; (2) removal of colon to the lower sigmoid; (3) removal of the rectum and remaining sigmoid. To date the last stage has been necessary in only two of our patients.

Ether anesthesia is used. A long left paramedian incision is made and the colon removed either from right to left (R. H. M.) or from left to right (L. S. M.). We believe strongly in preservation of the omentum, suturing its under surface to the transverse mesocolon and to the posterior peritoneum in the splenic and hepatic regions where the posterior peritoneum is less well defined and the retroperitoneal surfaces more difficult to cover. The entire bed of the colon is carefully covered either with omentum or peritoneum (Fig. 2). If not previously done the space between the ileostomy and right abdominal wall is obliterated.

The upper end of the lower segment may in an occasional case be turned in and dropped back into the pelvis. In most cases, however, we prefer bringing it out of the lower end of the wound not only because of the saving of time but also because we believe it to be safer. In one of our earlier cases the rectal stump and failure to preserve the omentum were responsible for a fatal acute small bowel obstruction occurring three weeks after the patient left the hospital.

If continued rectal bleeding or peri-anal infection makes it desirable to remove the remaining segment of bowel, this is done by a combined abdomino-

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perineal operation or, if the stump of rectum has been turned in and dropped into the pelvis, by excision from below.

SUMMARY

One hundred forty-nine cases of idiopathic ulcerative colitis admitted to the Massachusetts General Hospital during the past 20 years have been reviewed.



FIG. 2.—The sigmoid has been divided, the distal end with the clamp in place and covered with gauze is brought out through the lower end of the wound. The mesentery has been divided close to the bowel as far as midtransverse colon, the omentum being carefully separated from colon. The posterior peritoneum has been closed as the operator proceeds, the large uncovered area at the splenic flexure being covered with omentum which is then sutured to the transverse mesocolon. If the operator prefers the operation may begin by division of the terminal ileum and proceed from right to left.

The important general aspects of the disease have been considered.

The indications for, the principles of technic, and the immediate results after ileostomy, subtotal and total colectomy are discussed.

CONCLUSIONS

(1) Surgery in carefully selected cases has an important place in the management of the intractable and more serious cases of idiopathic ulcerative colitis.

(2) Ileostomy is the operation of choice. Preceded and followed by blood transfusions and other indicated measures it is frequently a life-saving procedure.

(3) It was ultimately performed on 40 per cent of patients admitted to the wards of the Massachusetts General Hospital.

(4) Approximately 40 per cent of patients surviving ileostomy will later require removal of the diseased colon.

(5) The results after subtotal colectomy are excellent.

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DISCUSSION.—DR. RICHARD H. MILLER (Boston, Mass.).—I shall consider briefly certain technical points which we feel are of interest and importance.

The operation of ileostomy, which would at first thought seem to be simple, is, as a matter of fact, fraught with danger. The ileostomy should be made within the last 12 inches of the small intestine and the proximal loop should be lower than the distal loop. The opening in the muscle should not be larger than enough to accommodate two fingers. If it is larger than that, there is great tendency to herniation of the bowel, and if it is smaller, there will often develop obstruction at the point where the bowel emerges through the abdominal wall.

It is not uncommon to see intestinal obstruction from the simplest sort of twist or kink in the bowel. It is not definitely represented here, but we have seen instances of the typical picture of mechanical obstruction where there was nothing save the least bit of kinking where the ileum traverses the anterior abdominal wall.

At the time of doing the ileostomy, exploration should never be performed, because there is altogether too much danger of setting up a general peritonitis. The exploration and palpation of the large intestine has been compared to the situation existing in a canvas tent during a rain storm. If one stands inside the tent, the roof will be perfectly dry on the inside until one draws a finger along it and then drops of water will appear and drip down. That may occur when one rubs one's hand over the diseased colon.

We have seen instances in which papillomata develop on the exteriorized mucous membrane as a result of the constant irritation of the ileostomy bag, and have been obliged to remove them surgically.

I want to emphasize again what Doctor McKittrick said about the necessity of preservation of the great omentum in cases in which the colon is removed. We believe very strongly that its preservation results in greater protection against later intestinal obstruction. At first thought it might seem a bit difficult, but when you come to do it you will find that the transverse colon can be dissected free without the slightest trouble.

A last word about the rectum. Doctor McKittrick has usually saved the rectum and colon, whereas I have taken it out farther down and frequently turned in the stump. To my surprise there have been occasional instances where the disease has peristed in the rectum in spite of the fact that the patient's general condition has greatly improved. Again, in another case just recently, it has been necessary to remove the remaining rectum because of persistent bleeding. The removal of the existing stump is not difficult if one will simply open the rectum, insert the forefinger into its lumen, and so determine definitely where the upper end of the stump is, by doing which one avoids the risk of possibly opening the peritoneal cavity.

In all these cases which we have followed of recent years, we have seen definite improvement and we believe that ulcerative colitis is a disease in which surgery plays a very important rôle. There are a certain number of cases demanding ileostomy, and of those who are improved by ileostomy, a certain percentage, about 40, require colectomy, and colectomy is, comparatively speaking, a safe procedure.

We have a number of patients going about their business today, well satisfied with their artificial anus, able to handle it cleanly and without particular difficulty, and those are ones who, without some type of surgical intervention, such as this, would certainly have died of their disease a long time ago.

DR. VERNON C. DAVID (Chicago, Ill.).—The informative review of the surgical side of ulcerative colitis just presented by Doctors Miller and McKittrick emphasizes the seriousness of the disease and the relatively frequent necessity of the performance of ileostomy and less frequently, colectomy. In the performance of ileostomy, it has been our custom to omit exploration of the abdomen as it has frequently been found that free fluid and fibrinous exudate are present in the peritoneal cavity due to its involvement by extension from the inflamed colon.

To supplement the cases reviewed by the essayists I should like to comment on some data obtained from the care of 50 cases seen in private practice during the past ten years. The ages of the patients varied from five to 50 years and there were 31 females and 19 males in the group. The cases could be relatively easily divided into two groups of mild and severe examples of the disease. Both groups were composed, in the main, of patients who had suffered with the disease from one to 16 years. In the group of mild cases, the general health of the patients was little affected; their color and weight was practically normal; there were only a few acute exacerbations of the disease, and the ulceration was usually confined to the rectum, sigmoid and descending colon. In most of the mild cases the roentgenologic examination of the colon showed but slight narrowing of the affected bowel and lack of haustration, but no foreshortening or stricture of the colon. On the other hand the severe cases exhibited fever, loss of weight, anemia, almost constant diarrhea, involvement of practically the whole colon by the disease and

a distinctly downward course. In this group two patients had an acute fulminating course with death within six weeks in spite of ileostomy.

The bacteriology of most of the cases was carefully considered, many not only having routine examinations of the stools but aerobic and anaerobic cultures were made from material taken from the rectal ulcers. The results of these examinations were anything but uniform. *B. coli*, streptococci (often hemolytic) of various types, dysentery bacilli, *C. welchii*, and many other organisms were found. Usually the most carefully studied cases showed a mixed flora.

There were 28 mild cases treated by neutral acriflavine enemata and high vitamin diet. Most of these patients were improved and four patients were apparently cured, although it is our belief that the cure is relative, due to the well known tendency to relapse. Surgery was not resorted to in any of these patients; there were few complications and no deaths.

There were 22 severe cases which had lasted from a few weeks to '16 years. Complications occurring in this group were:

(1) Joint swelling.....	2
(2) Leg ulcers.....	1
(3) Marked stricture of the bowel.....	5
(4) Perirectal abscess.....	5
(5) Rectovaginal fistulae.....	4
(6) Polyps of the colon.....	1
(7) Ulceration of labia and clitoris.....	1
(8) Infection of abdominal wall from involvement of the ileum.....	1
(9) Subacute peritonitis of various grades.....	5

These patients had the following major surgical procedures carried out:

Ileostomy.....	7 with 2 deaths
	3 of these patients were radically improved; 2 moderately improved.

We advised ileostomy in seven other patients but it was refused.

Three of these patients subsequently died.

Colectomy—One patient with marked stricture of the colon following ileostomy, marked improvement.

Appendicostomy—None in our hands but one case ileostomized had had a previous appendectomy.

<i>Results:</i> Dead.....	6
Improved with ileostomy.....	5
Treatment with diet, acriflavine, <i>etc.</i> , moderately improved.....	5
Condition the same.....	5

DR. CHARLES C. LUND (Boston, Mass.).—I am not able to present a study of as large a series of cases as either Doctor McKittrick or Doctor David have reported, but I have studied intensively three of these acute cases in my own practice, and one that I have recently labored over was a patient of my father's.

All these were very severe. They all had ileostomies. Two had complete colectomies and removal of the rectum. I have a distinct impression that in the severe cases fairly early ileostomy is definitely indicated, and at not too late a date after that, unless they make a more remarkable improvement than usual, a total colectomy is indicated.

The case that I have just finished began 15 years ago, at which time my father did an ileostomy. Ten years ago he removed the colon, and she

returned to pretty nearly normal life. Six months ago she began to go downhill again with discharge from the remaining sigmoid and rectum. On removal of the rectum a quite remarkable thing happened. Her ileostomy was for some reason or other a little more contracted than usual and had a very small opening. This never bothered her because her ileostomy discharge was always completely liquid.

Five days after removing the segment of rectum which, of course, was quite distant from the ileostomy, the ileostomy contents thickened so much that on the eighth day I had to enlarge the ileostomy. There is apparently some reflex acting that is extraordinarily interesting and will warrant a lot of further study.

DR. DANIEL FISKE JONES (Boston, Mass.).—Wished that reporters might be a little more accurate in regard to what they were talking about. It is quite confusing when one man says he cures 90 per cent of these cases by vaccines or serums, when the rest of us cannot cure even 1 per cent nor $\frac{1}{2}$ of 1 per cent. We would like anybody to show a series of cases of chronic ulcerative colitis of any duration at all, that you can call chronic, that have been cured by vaccines or by anything else. There is a very definite acute ulcerative colitis which is a very serious disease and which will kill a large number of patients, whether you do an ileostomy or not. Occasionally, I think that an ileostomy will save a patient.

The case Doctor Lund spoke of, whom I saw with him in consultation, was an acute ulcerative colitis following delivery. She had very deep ulcerations entirely through the posterior wall of the rectum as well as through the vaginal wall, and perirectal abscesses. An ileostomy was done and the sphincter cut, and the colon irrigated. She recovered. One hundred per cent do not get well, and never will, but if you let them alone they will certainly die, I believe, in a little higher percentage than if you do an ileostomy.

You will be very sorry for yourself if you do an ileostomy on a large number of these cases. Doctor McKittrick said 35 per cent died following ileostomy. Let us find out what percentage die if you let them alone. I am not referring to chronic ulcerative colitis, but to acute cases.

Few men seem to state definitely whether they are talking about acute, subacute, or a chronic ulcerative colitis which can be definitely diagnosed by the history and proctoscopic examination. Let us be reasonable about this matter and try to talk about the same condition instead of going on as we are at the present time.

There is a group of men who do not believe in ileostomy. As an example, a boy nine years old had chronic ulcerative colitis, was given vaccines for a long period and by men who know how to use them. He was sent to Colorado. He went down to 50 pounds there, never went to school, and could do nothing other boys of his age did. He was prevented from having an ileostomy for ten years. That boy was operated upon recently and within two months he weighed 25 pounds more than he had ever weighed before in his life. He is going to school now and drives an automobile. I am sure you gentlemen would be a fair if a case like this were put to you and would admit that ileostomy was an excellent procedure.

Let me impress upon you that ileostomy does not cure the disease. Ileostomy "cures" your patient. A case in point is a patient who, after ileostomy, gained markedly in weight and was quite well for four and one-half years. She was tired of the ileostomy and wanted something done. I therefore sent her to those who cure 90 per cent of their cases. I was told that this was a healed colitis. She was sent back to me to close the ileostomy

as she was cured. Three months after her return she nearly died of hemorrhage, and in another three months she had another hemorrhage, and in another three months I took out her colon. It may have been the vaccine or the serum that caused the ulceration in the colon, but when I took it out there was not a piece of mucous membrane as large as the nail of your little finger in the colon. If anybody can prove to me that vaccines will cure such cases as that, I should be glad to have it shown.

I think it is too bad to go on saying that ileostomy should not be done. I am sure it is keeping a lot of patients in bed, and it is not only keeping the patients in bed, but in children it is keeping the mother from doing anything but attending the child. I think it is much better to have a "cured patient" even if the disease is not cured.

There is a perfectly definite type of chronic ulcerative colitis which is progressive and has, so far as I know, never been cured. You may be able to cure early mild cases. I do not know what the difference is, but I know that if you get a real case of chronic ulcerative colitis which you are able to call chronic, that has gone on for a year or two, very few if any cases in this country have been really cured. I am quite sure that if we could only get to talking the same language about this disease we might get somewhere, but with the nomenclature as varied as it is at the present time and with so little said about the proctoscopic and roentgenologic findings, we certainly shall never get anywhere.

DR. HOWARD L. BEYE (Iowa City, Iowa).—Our experience at the University Hospital consists of 39 cases which have been operated upon. Fifty-one operations have been performed. Our results in respect to ileostomy have been very discouraging. There have been 12 cases. Of these there was an immediate or hospital operative mortality of 50 per cent (six cases). Of the six cases that survived, two of them subsequently died of the disease and two of them were so dissatisfied and discouraged with the ileostomy that they sought elsewhere a reestablishment of the continuity of the bowel and died following that.

One of our patients did fairly well. The bowel seemed to be improving and because the ileostomy was so discouraging to this patient, a young girl, I reestablished continuity. She survived, but did not do well. I subsequently did a compromise colostomy and she is getting along fairly well. She will come subsequently to partial colectomy.

We have had only one case, therefore, in which there has been an adequately functioning ileostomy who led a relatively normal life with this handicap. He has subsequently had a total colectomy. So, as a compromise to this very discouraging condition which develops from ileostomy, we have gone back to appendicostomy and cecostomy to give it a trial. We have been doing this now about four years and have 21 cases that have been treated in this way, realizing that it is purely a compromise.

We have found that frequently a very striking degree of improvement will follow this. The improvement, however, takes place in its completeness in the first year. Beyond that time the patient will not improve further, in our experience. In some cases the improvement has been very striking. We introduce a very small tube, about an eighth or ten French catheter in the appendicostomy opening. Irrigation is carried out once or twice each 24 hours, using 1,000 cc. of tap water. Our results have been as follows:

There have been five deaths, two of which were in the hospital and three subsequently from the disease (24 per cent). There has been one complete cure by the strictest standard that one can erect. This has been a clinical cure. There has been no cure as far as the condition of the bowel is con-

cerned, as shown by barium enema. This patient, an adult, had 15 or 20 stools per day, lost 85 pounds in weight. He is now doing heavy farm work, has one stool a day, and is perfectly strong. This has been three years ago. His tube has been removed and the appendicostomy opening which failed to heal has been closed by operation. We have had another case not quite so marked, but the improvement has been very striking, a gain of 20 pounds in weight, has two stools a day, does heavy farm work, but still wears his tube. We have had eight cases showing slight to considerable improvement. One case did not improve at all. I think he was made worse. Of the entire group, there have been five patients who have subsequently had either colostomy or colectomy.

We have learned, when we utilize this method of treating these cases that we must anticipate, except in the very exceptional case in which we might get a clinical cure (we do not expect that), that the tube must be worn permanently. If the patient pulls the tube out, or it becomes dislodged during the first year, or if the patient ceases to carry out irrigation treatment, there will be a return to the former condition.

As a compromise between ileostomy and appendicostomy, we have carried out colostomy in 11 cases. This is relatively simple and easy to determine upon if one is dealing with a regional colitis involving, say, the left half of the bowel or sigmoid, as it sometimes will. However, in four cases I have compromised to the extent that I have performed a colostomy through the midtransverse colon in bowel that was diseased, but relatively less diseased than on the left. I have made this compromise because of our discouraging experience with ileostomy. One patient died and three patients have gotten along very well, much better in fact as far as their social life is concerned than those with an ileostomy.

In our small group we have had one total colectomy, five partial, and three others in our series are candidates because of the continued symptoms which they have following colostomy or appendicostomy. There have been no fatalities in our series of colectomies.

DR. LELAND S. MCKITTRICK (Boston, Mass.).—In reply to Doctor Beye, we went over our records quite carefully relative to the appendicostomies which were quite popular in the early part of the series, and found nothing which could convince us that appendicostomy had any effect, whatsoever, on the disease. We believe quite firmly that medical treatment as now carried out at the Massachusetts General Hospital accomplishes as much as appendicostomy accomplished in the past, and are convinced that if operation becomes necessary external diversion of the fecal stream is essential.

We should dislike very much to leave the impression that we underestimate the inconvenience of an ileostomy or that we overestimate its value. It may be that our New England patients are somewhat euphoric, and are less disturbed by the ileostomy than those elsewhere. But when you have a young man tell you that he swam two miles last summer, feels fine and is happy with his ileostomy, it cannot be as bad as some would have us believe.

However, the patient who has an ileostomy must know what the disease means and have been very uncomfortable. It must either have saved his life or restored him from a state of invalidism to one of relatively good health. Moreover the patient must want to live.

We believe ileostomy to be permanent. It should be done under novocaine without exploration and without removal of the appendix. The mortality should not exceed 15 to 20 per cent, and that approximately 50 per cent of the survivals should be able to carry on a reasonable life, and that the other 50 per cent will eventually come to colectomy.

REGIONAL ILEITIS

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OUR attention was first directed to this lesion as a clinical entity in January, 1932. A young man, aged 27, was admitted complaining of colicky abdominal pain, diarrhea and loss of weight. He had had an appendectomy 12 years before. An abdominal mass below the umbilicus was palpable. At operation the mass was found to be composed of loops of terminal ileum, swollen, engorged and agglutinated. The mesentery was tremendously thickened and contracted. Tuberculosis or possibly malignant lymphoma seemed the most probable diagnosis. In mobilizing the mass for exploration, uncontrollable hemorrhage was encountered, requiring resection and anastomosis between the ileum and ascending colon. Pathologically the process proved to be a chronic inflammatory ulcerative enteritis involving the terminal ileum without evidence of tuberculosis or malignancy. The cecum was entirely free of disease.

Shortly afterward, at the meeting of the American Medical Association, Crohn and his associates described their cases of regional ileitis and separated them as a subgroup from the benign granulomata. It was evident that the above case fitted absolutely into their group. Our attention having been directed to the symptom complex accompanying the underlying pathologic process, we have since made a correct preoperative diagnosis on several occasions. Eleven definitely proved cases are available for analysis, including one case of ileocecal resection performed in 1931 which has since been reviewed and recognized as belonging to this group. The other cases have been operated upon during the past three and one-half years. Eight of the 11 patients were of Jewish extraction. Whether or not there is a racial predisposition to this disease I cannot say, but at the Beth Israel Hospital we have encountered a greater number than in other larger hospitals in this community.

Our statistics confirm those previously published. It is a disease pre-eminently of young adults. The youngest was 14 years, the oldest 56 years and seven occurred in the twenties. In this series, males were more often affected than females. In five cases there had been an appendectomy from 18 months to 12 years previously. One of these had been operated upon at another hospital two years before and the abdomen drained, though the pathologist reported chronic appendicitis. Two to three months later a fecal fistula developed in the scar. In view of the absence of acute inflammation in the appendix it seems probable that some other acute inflammatory process was present at the primary operation for which drainage was indicated, though no other procedure was undertaken. In another case the symp-

toms were of 21 months' duration. Appendectomy was performed three months after onset without relief of symptoms. At a subsequent operation a chronic abscess cavity between coils of ileum and inflammatory adhesions between the ileum and sigmoid, apparently the forerunner of a fistula, was encountered. Such histories and operative findings strongly suggest that the regional ileitis was present; but its significance not recognized, at the time of the primary appendectomy.

TABLE I

	Cases
Age*	
Under 20 years.....	3
20-30 years.....	7
Over 30 years.....	1
	— 11
Sex	
Male.....	8
Female.....	3
	— 11
Appendectomy	
1½-12 years previously.....	5
* Youngest, 14 years (2 cases); oldest, 56 years.	

The classic symptoms frequently resemble those of mild ulcerative colitis—namely, fever, diarrhea, and loss of weight. Eventually partial obstruction of the small intestine may occur. There is usually a palpable mass in the right lower quadrant. The maximum intensity of the process is in the terminal ileum and involves the ileocecal valve but not the cecum. The lesion becomes less pronounced as it progresses upward along the small bowel and usually involves not more than one to three feet of lower ileum. There is a marked tendency to the formation of sinuses, leading chiefly to adjacent coils of ileum, the sigmoid or cecum, or externally through the abdominal wall at the site of a previous laparotomy scar. Abscess formation between coils of ileum or the leaves of the mesentery is common from slow perforation.

Crohn grouped the cases into four clinical types, representing progressive stages in the disease.

Group 1.—This group shows signs of acute intra-abdominal inflammation, indistinguishable preoperatively from acute appendicitis. There are pain and tenderness in the right lower quadrant, cramps, fever and leukocytosis. A mass may be palpable. At operation, the terminal ileum is reddened, greatly thickened and bleeds readily, and its mesentery is edematous, containing enlarged hyperplastic lymph nodes. The appendix may be reddened and involved by contiguity but it shows no mucosal inflammation.

Group 2.—The second stage presents symptoms suggestive of ulcerative colitis. There is colicky abdominal pain and looseness of the bowels, at

times with blood and mucus. There is slight fever, malaise, marked loss of weight, and anemia, often severe, develops.

Group 3.—The stenotic stage follows the ulcerative phase. Due to the extreme thickening of the bowel wall the lumen of the bowel becomes constricted and may be partially obliterated by the healing of the mucosal ulcerations. Usually the narrowing is most evident near the ileocecal valve, while above, in the more recently involved portion of the bowel, the earlier ulcerative phase predominates. The symptoms are those of partial obstruction of the small intestine. In this stage a mass is usually felt.



PRINT 1.—Examination three hours after ingestion of barium shows slightly dilated loops of small bowel in the pelvis. The terminal ileum shows an irregular narrowing, most marked just proximal to the ileocecal valve. There is an ovoid area of increased radiance, about 2 cm. proximal to the valve, which is suggestive of a polyp. There is also a very fine line of barium just proximal to the polyp, directed toward the cecum, which may be due to a fistula. There is also a slight irregularity of the medial wall of the lower pole of the cecum.

PRINT 2.—There is no evidence of delay, obstruction or gross irregularity of the colon. The ileocecal valve is patent. The terminal 8 cm. of the ileum are irregularly constricted. Just proximal to the ileocecal valve there is a thin column of barium directed upward, about 1½ cm. long, which is probably due to a fistulous tract.

Group 4.—The stage of fistula formation. This is a late manifestation of the disease and is the result of slow perforation of the ulcers. Frequently multiple fistulae are formed. They may open externally through the abdominal wall or they may be internal and can at times be demonstrated by roentgenologic examination of the gastro-intestinal tract. In contradistinction to appendiceal fistulae, which tend to heal, such fistulae are persistent and resist operative attempts at closure.

In a consideration of the differential diagnosis, ileocecal tuberculosis, ulcerative colitis, lymphosarcoma, actinomycosis and carcinoma must be borne in mind. The diagnosis of regional ileitis is suggested when one encounters

in an adolescent or young adult the symptoms of chronic small intestinal obstruction accompanied by signs of a low grade inflammatory process with mild fever, slight leukocytosis, loss of weight, a variable degree of anemia and usually a somewhat tender mass palpable in the right lower quadrant or by rectum. The bowel habit is irregular, constipation alternating with diarrhea. Mucus and at times blood are present in the stool.

Conclusive evidence to establish the diagnosis is often furnished by gastrointestinal roentgenography. By barium enema the colon is normal except for a possible pressure defect caused by the mass of agglutinated terminal ileum or the presence of ileocecal fistulae. Occasionally a fistulous tract running to the sigmoid or elsewhere in the colon is demonstrated. If the stenosis is not too great, reflux through the ileocecal valve may demonstrate a narrow, tortuous and fixed terminal ileum. As in other types of obstruction, careful consideration should be given before recourse to the barium meal, as complete obstruction may be initiated. Roentgenography will show the terminal ileum narrowed and fixed for a variable distance. Areas of increased radiance in the narrowed lumen denote polypoid masses of hypertrophied mucous membrane. Above the obstructed segment the bowel is dilated and the passage of the opaque medium is delayed.

The etiology is obscure. The appendix has been implicated by Homans,⁹ based on the fact that in the two cases coming under his observation one showed ulceration and the other was partially destroyed by fibrosis. He maintains the vascular relations of the appendix are more favorable to ileal than to cecal involvement. Furthermore, removal of a diseased appendix frequently precedes the onset of the symptoms of regional ileitis. Our experience leads us to believe, however, that an unoffending appendix is not infrequently removed under the erroneous impression that it accounts for the symptoms and the true pathologic condition is unrecognized. In none of our cases where appendectomy had not previously been done was there evidence suggestive of primary appendiceal involvement or ulceration of the mucosa, though frequently it was enmeshed in the inflammatory mass by peri-appendiceal adhesions.

Usually the lesions are so chronic when the case comes to operation that a mixed culture is reported bacteriologically. The only bacteriologic finding of significance that was obtained in this series was in a relatively early case with symptoms of eight weeks' duration. At operation there was a considerable excess of straw-colored fluid. Cultures from this fluid, from the cut surface of the hypertrophied mesenteric lymph nodes and from the deep surface of the intestinal ulcerations, all yielded an anaerobic streptococcus in pure culture. The patient made a smooth convalescence following primary resection.

Repeated efforts by culture, staining reactions and guinea-pig inoculations have failed to demonstrate the tubercle bacillus.

The pathology is characteristically confined to the terminal ileum, ending

abruptly at the ileocecal valve where the process shows its greatest activity, and extending upward for a variable distance, usually a foot or two, where it stops, though not quite so sharply as it does at the ileocecal valve. The involved segment and its mesentery are enormously thickened and doughy without much distortion of the serosal surface except in the more advanced cases

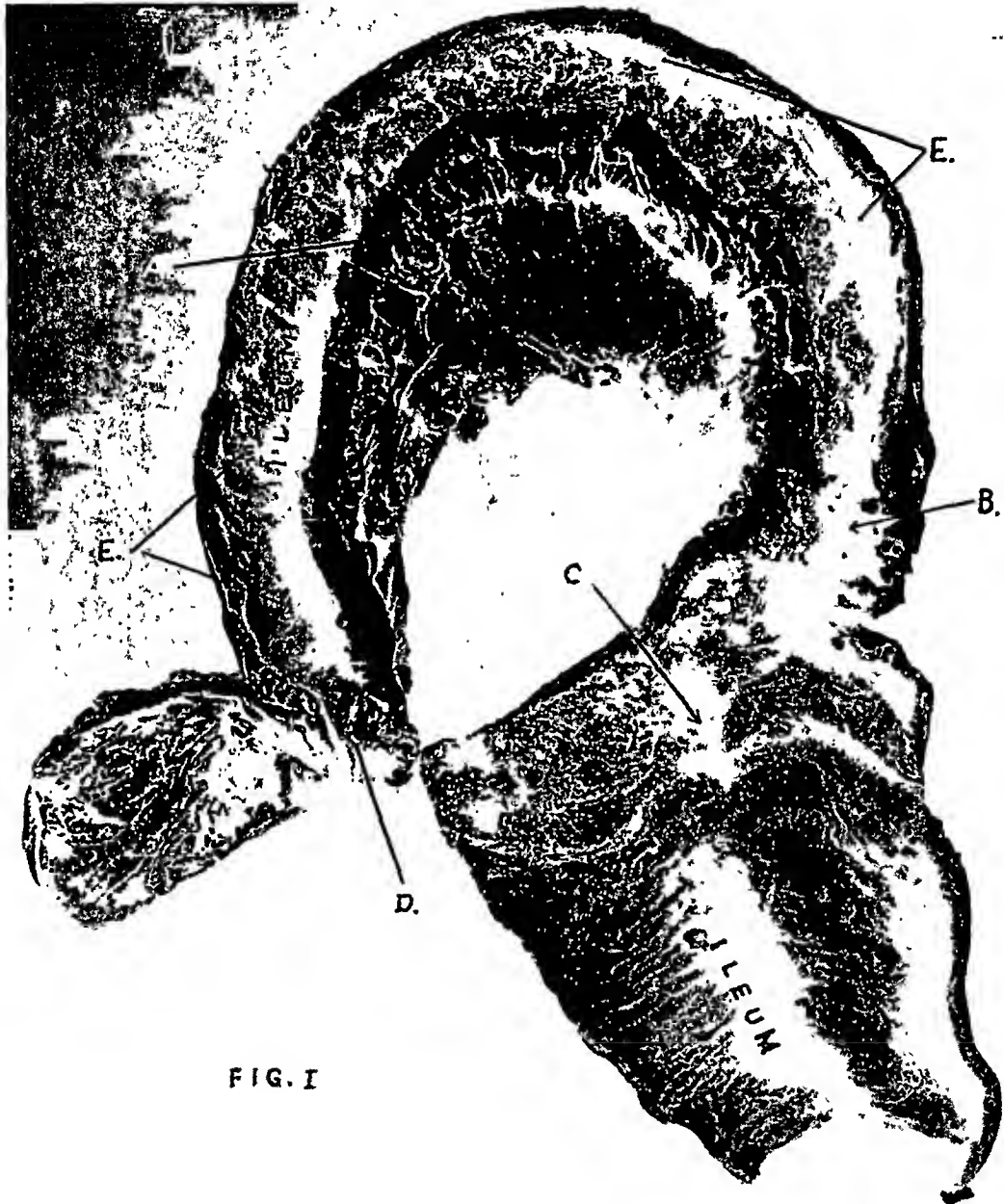


FIG. I

FIG. 1.—(A) Thickened bowel wall. (B) Greatly constricted zone. (C) Dilated ileum. (D) Ileocecal valve. (E) Ulcers.

in which sinuses have formed with resulting deforming adhesions. These sinuses, as already stated, may lead to other coils of ileum, to the cecum, sigmoid or abdominal wall. There is usually some clear free fluid in the peritoneal cavity and the peritoneal surfaces are moderately hyperemic and frequently present a granular appearance simulating slightly the lesions of miliary

REGIONAL ILEITIS

Fig. 2.—(A) Polypoid. (D) Ileocecal valve. Thickened ileum of process.

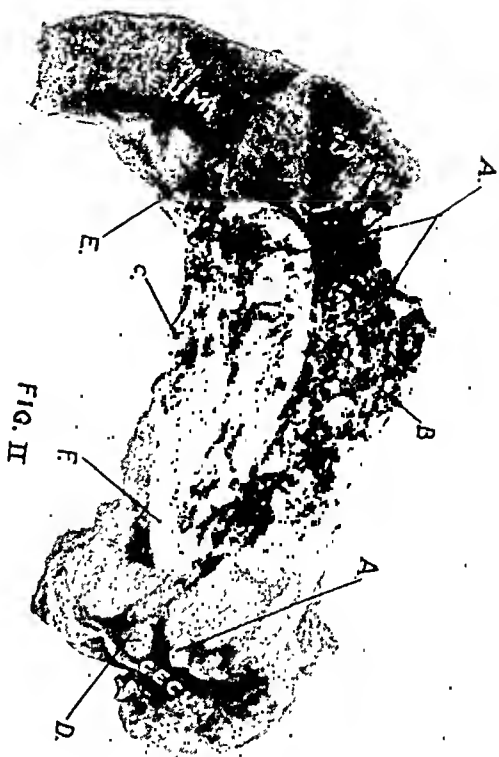


Fig. 3.—(A) Thickened wall of ileum. (B) Thickened mesentery. (C) Polypoid. (D) Ileocecal valve. (E) Edematous mucosa.

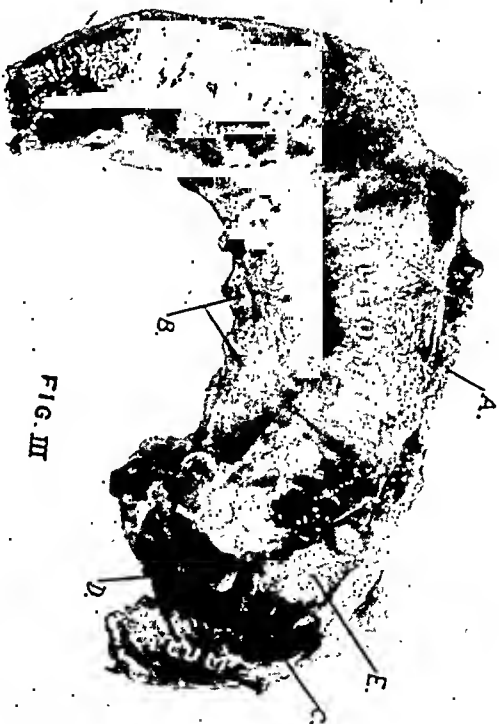


Fig. 4.—(A) Thickened wall of ileum. (B) Indurated mesentery. (C) Serosal roughening. (D) Mesenteric adenitis.

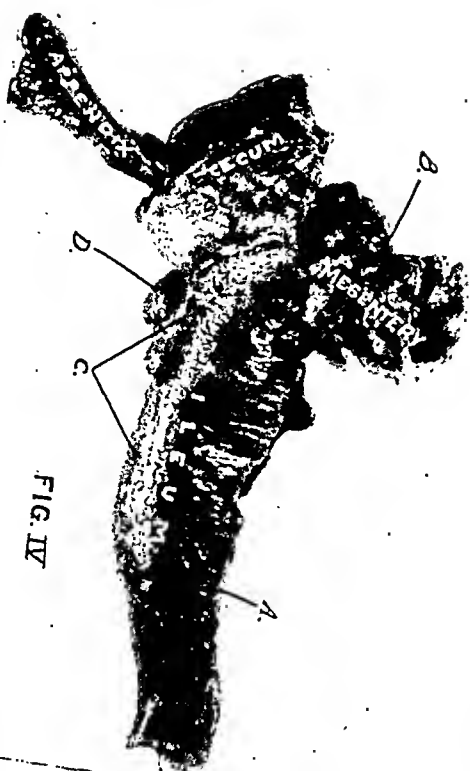


Fig. 5.—(A) Appendix. (B) Mesenteric adenitis. (C) Thickened wall of ileum. (D) Edematous mucosa.



tuberculosis. Numerous hyperplastic mesenteric lymph nodes are found. The cut surface of the gut wall shows the layers especially clearly defined due to



FIG. 6.—(A) Superficial ulceration. (B) Edema of mucosa. (C) Non-specific inflammatory reaction.

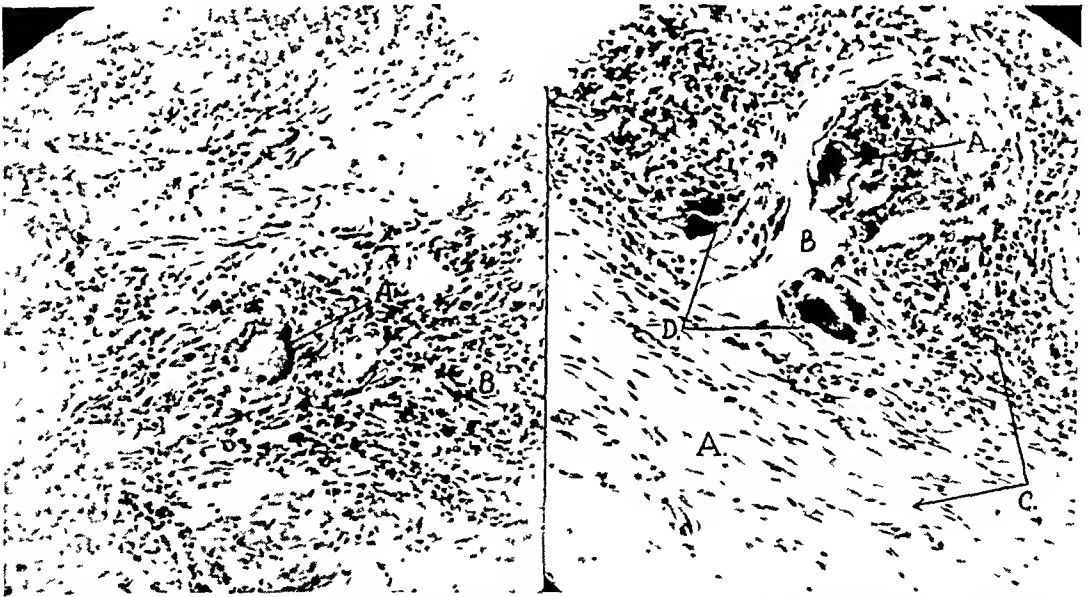


FIG. 7.—(A) Isolated giant cell. (B) Non-specific inflammatory reaction, monocytes and lymphocytes.

FIG. 8.—(A) Marked edema with separation of fibroblasts and ganglion cells. (B) Dilated lymphatics. (C) Edema out of proportion to cellular reaction. (D) Collection of giant cells

a diffuse edema which is particularly marked in the submucosa and subserosa. The mucosal surface has lost its villous fringes and shows instead a shiny

cobblestone-like surface with numerous superficial ulcers which tend to concentrate along the mesenteric border. The ulcers show little or no reaction at their edges or base but now and then a sinus can be traced from the base through the wall into the mesentery for a short distance. In the advanced cases such sinuses finally penetrate the mesentery and communicate with neighboring structures. It is only in this stage that a fibrous tissue reaction of any consequence appears.

Microscopically the process resembles a low grade inflammatory reaction characterized by an enormous widespread edema with a mild cellular reaction showing lymphocytes, plasma cells, monocytes and a few eosinophiles. There is little or no fibrin or polymorphonuclear leukocytic reaction except in the

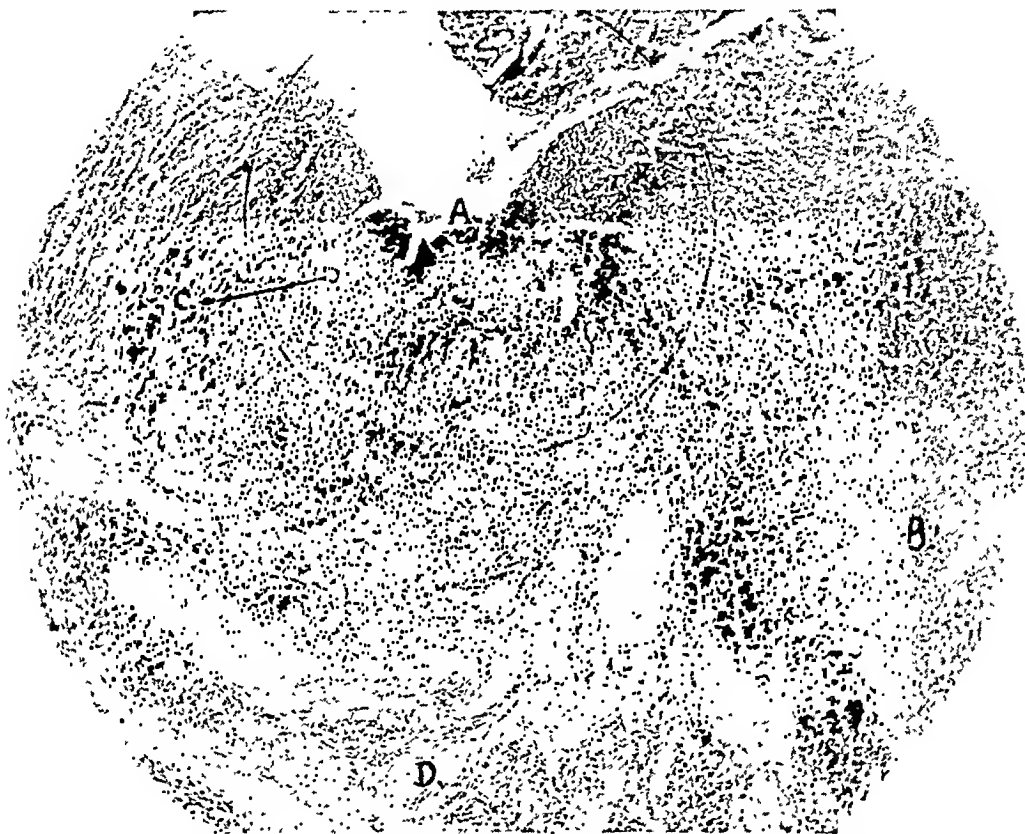


FIG. 9.—(A) Mucosal ulceration, epithelium destroyed. (B) Necrotic area communicating with ulcer forming sinus. (C) Isolated giant cell. (D) Non-specific inflammatory reaction.

region of the ulcers or sinuses. Minute areas of necrosis are scattered about which here and there become transformed into "epithelioid tubercles" but they differ from the picture of tuberculosis in that multinuclear giant cells, though frequently seen, are not found in conjunction with the monocytic cells forming the tubercle. The reaction in general is not unlike what one might expect from a rather avirulent streptococcus infection, an anaerobic strain of which was cultured in pure form from the lymph nodes, peritoneal fluid and from the ulcers in one of our cases.

It is possible that at times lesions in the early stage of the disease may undergo spontaneous resolution, but more frequently they progress to a sub-acute or chronic stage. In one or two instances an unconfirmed diagnosis of regional ileitis has been made in this clinic in which resection or other curative

measures have not been attempted and in which spontaneous cure has apparently resulted. We have operated on only one case that might have been placed in the early phase of the process. Here the signs were of acute right lower quadrant inflammation. Surgery was considered advisable on the basis of a probable appendiceal abscess and when the pathology was revealed an immediate resection and anastomosis was done with prompt recovery. The question may well be raised whether or not a procedure of this magnitude was indicated in the early stage of the disease and whether a temporary ileostomy or ileocolostomy might not have sufficed. In answer it can be said that the disease tends to progress and where graded procedures have been employed we have generally found that the involved segment of bowel has later developed some form of complication, either abscess or fistula, that has rendered resection much more difficult and hazardous. We have had no case in which a cure was accomplished short of this procedure.

In view of the progressive character of the lesion, the treatment is definitely surgical, but the hazards of operative intervention should be emphasized. Operative maneuvers may activate a latent infection and cause a fatal peritonitis or septicemia. Drainage should be avoided when possible as it frequently leads to the formation of fistulae. Resection of the involved segment in one or multiple stages is the ideal procedure. Technically the operation is difficult due to the severe hemorrhage caused by mobilization of the bowel, the extreme thickening of the mesentery and at times the presence of complicating fistulae. The cecum is removed with the terminal ileum, as the ileocecal valve is usually involved, and an end-to-side or side-to-side anastomosis established with the ascending colon. An ileostomy to relieve the suture line is often advantageous.

TABLE II

Operative results in 11 cases

Recovered.....	7	64%
Died.....	4	36%

One stage ileocecal resection, 6

Recovered.....	5
Died.....	1
Fulminating peritonitis, ? septicemia 40 hrs. p.-o.	

Attempted stage resections, 5 (All cases complicated by fistulae or abscesses)

Recovered.....	2
Died.....	3

Completed stage resections, 3

Recovered.....	2
Died.....	1

Multiple pulmonary infarcts and bronchopneumonia 3 weeks after Mikulicz resection.

Incompleted stage resections, 2

Died.....	2
1. Fecal fistula and peritonitis; died on 9th p.-o. day.	
2. General peritonitis. Died 36 hrs. p.-o.	

The majority of patients present themselves with definite obstructive symptoms or with abscesses or fistulae, and the indication for surgical intervention is clear. A multiple stage procedure may be indicated with drainage of an abscess as a first step, followed by ileocolostomy and finally resection.

Our best results have been attained by the one stage ileocecal resection and closure without drainage. This type of operation is more readily applicable to the earlier stage of the disease where complications are minimal. Six patients have been so treated with one death. The latter patient was in excellent condition following operation, but died some 40 hours later of a fulminating peritonitis with a probable septicemia.

In five cases resection by multiple stages was attempted. All presented extensive complications. Two patients succumbed following ileocolostomy. In one there was involvement of the terminal eight inches of the ileum with extension to the cecum where a perforation was encountered. Lateral anastomosis with drainage was done. A fecal fistula and peritonitis developed, and the patient died on the ninth postoperative day. The other patient was a poor operative risk with extreme emaciation, anemia and secondary neurologic symptoms. An ileocolostomy was done, but a small chronic granulating cavity was inadvertently opened. It lay between adherent folds of mesentery and contained no gross purulent exudate. The patient developed a virulent peritonitis and died in 36 hours.

Resection was performed in multiple stages three times, with one fatality. The Mikulicz technic was employed twice, the fatal outcome occurring in one of these. The patient was the oldest individual in the series. Preliminary drainage of an ileocecal abscess was followed by resection. Multiple pulmonary infarcts occurred during the second week, and death occurred 21 days after the second operation.

The mortality in the 11 cases comprising this series has been 36 per cent. This high figure may perhaps be accounted for by the fact that six of the cases presented extensive complications at the time of admission. Three of the four deaths were caused by postoperative peritonitis. The remaining death followed multiple pulmonary infarcts. The underlying infection, in spite of its chronicity, we believe to be a virulent one. Adequate resection is apparently curative, as there have been no recurrences to date.

CASE REPORTS

CASE I.—Office, No. 9073. March 13, 1930. Male, aged 29. Four years ago onset of epigastric discomfort and occasional vomiting. For ten months attacks of vomiting, sweating and chills. No pain. For nine weeks gas and abdominal distention, pallor and constipation. For ten days colicky pain, nausea and vomiting, diarrhea with watery stools and mucus. Weight loss 35 pounds in four years.

Significant Physical Findings.—Distention, right lower quadrant tenderness. Question of mass.

Laboratory Data.—Hemoglobin, 65 per cent; red blood cells, 4,500,000; white count,

7,000. Stools contain mucus. Guaiac, negative. Preoperative. Roentgenographic Examination.—Small intestinal obstruction near ileocecal valve. Tuberculin test, negative.

Operation.—Lateral ascending ileocolostomy. Amber fluid. Agglutinated mass involving terminal ileum and cecum. Terminal eight inches of ileum greatly dilated. Improvement, but never free from symptoms.

Readmitted May 22, 1934. For seven weeks had had vomiting. Weight loss of seven pounds. No cramps, constipation, diarrhea or blood. Roentgenogram showed no evidence of obstruction but cecum flattened. Probable inflammatory mass at ileocecal valve.

Laboratory data.—Hemoglobin, 70 per cent; red blood cells, 4,300,000; white count, 11,000. Stools contained no mucus. Guaiac, negative.

Operation.—Appendectomy with drainage. Indurated mass involving terminal ileum and cecum. Hyperplastic mesenteric nodes. Terminal ileum hypertrophied and dilated. Remaining small bowel normal. Lateral anastomosis patent and functioning.

One and one-half months later fecal fistula was established at drainage site. Temporary spontaneous closure followed by malaise, chills, etc. Relief when fistula would reopen. Readmitted April 26, 1935.

Operation.—Resection of terminal ileum and ascending colon. Modified Mikulicz technic. Numerous ileocecal fistulae encountered. Good convalescence.

Pathologic Report.—The specimen consists of cecum resected about four and one-half inches distal to the ileocecal valve to which are attached about six and one-half inches of terminal ileum. A loop ileocecostomy has been performed, and the ends of this loop are also attached to the specimen, two and three-quarters inches of one end and one and one-half inches of the other. The mucosa of the ileum is diffusely and irregularly ulcerated. The ulcerations are shallow and ragged and tend to extend lengthwise along the longitudinal dimensions of the intestine. The largest measures one and five-eighths by five-eighths inches. The base is red, corrugated into longitudinal folds, granular, apparently bleeding from one small point. In addition to the ulcerations there are several small polypoid formations, sessile in type, the largest measuring four Mm. in diameter. They are firm, of the same color as the surrounding mucosa and not ulcerated. There is a marked constriction at the ileocecal valve where the circumference of the ileum measures only about one and one-quarter inches, and the ulcerations extend down to this point. The ileocecostomy is not remarkable. The anastomosis is apparently an old one and the operative site is in good condition. There are no ulcerations seen in the cecum.

Diagnosis.—Regional ileitis.

Comment.—The mucous membrane is partially replaced by cellular granular tissue which contains many eosinophilic leukocytes. The muscular coats are thickened by a chronic inflammatory infiltration and fibrosis. There are many lymphoid cell follicles, especially numerous in the submucosa. No epithelioid or giant cells are noted.

It is noteworthy that although the duration of the disease was nine years and ileocecal fistulae were present, pathologic examination of the resected specimen showed no involvement of the large bowel. Spontaneous development of an external fistula followed drainage. This case has been reported somewhat in detail as it is typical of the progressive character of this disease.

CASE II.—B. I. H., No. 12219. September 24, 1931. Male, aged 19. Intermittent right lower quadrant pain of two weeks' duration. Nausea for two days. Vomiting in past 24 hours.

Physical Findings.—Generalized abdominal spasm and tenderness in right lower quadrant. Right sided pelvic tenderness on rectal examination. *Laboratory Data.*—White count, 15,200. *Preoperative Diagnosis.*—Acute appendicitis. *Operation.*—Ileocecal resection and ileocolostomy. The terminal ileum and cecum were involved in a large, inflamed, edematous mass. About 24 inches of bowel were resected. Convalescence

stormy; fecal fistula and wound sepsis. Follow up clinic reports patient well. No gastro-intestinal symptoms. Wound well healed.

Pathologic Report.—There is a diffuse phlegmonous subacute inflammatory process of the entire bowel wall and mesenteric attachment with mucosal ulcerations. *Diagnosis.*—Regional ileitis. In good health four years later and free of gastro-intestinal symptoms.

CASE III.—B. I. H., No. 10207. January 1, 1932. Male, aged 27. Appendectomy in 1920. Abdominal distress for years. Two previous hospital admissions for colicky abdominal pain and obstipation. Present complaint—diffuse abdominal pain, most severe in left lower quadrant. Bowels irregular.

Physical Findings.—Hyperperistalsis, tenderness and question of mass in left lower quadrant. *Laboratory Data.*—Hemoglobin, 80 per cent; white count, 6,400; stool, negative. No preoperative roentgenologic examination was made.

Operation.—Resection 18 inches of terminal ileum. Lateral ileocolostomy, ascending ileostomy. Some free fluid present. Mesentery of ileum over one inch in thickness. Severe hemorrhage. Transfusion. Convalescence stormy. Bilateral bronchopneumonia. Partial wound separation. *Follow Up.*—Well and has gained weight. Incision well healed.

Pathologic Report.—Acute edematous and ulcerative enteritis. Regional ileitis.

CASE IV.—B. I. H., No. 13298. January 13, 1932. Male, aged 26. Dull intermittent right lower quadrant pain with exacerbations. Nausea. No bowel disturbance.

Physical Findings.—Tender, fixed, orange size mass in right lower quadrant.

Laboratory Data.—White count, 13,300. Roentgenographic examination showed no abnormality of colon by barium enema.

Operation.—Ileocolostomy transverse. No free fluid. Terminal nine inches of ileum inflamed and apparent extension to cecal wall. Four inches above ileocecal valve small perforation (fistula?) found near mesenteric border. Mesentery thickened. Appendectomy. Drained. Postoperative distention marked. Fecal fistula developed on seventh day. Died on ninth day, of peritonitis.

Pathologic Report.—Chronic appendicitis. No autopsy obtained.

CASE V.—B. I. H., No. 15261. July 18, 1932. Male, aged 14. Onset of periumbilical pain one and one-half years previously. Occasional attacks of vomiting becoming more severe. Lately diarrhea. Appendectomy three and one-half years before admission.

Physical Findings.—Emaciation. Rectal examination revealed soft, rounded, tender mass palpable through anterior rectal wall. *Laboratory Data.*—Hemoglobin, 65 per cent; red blood cells, 5,400,000; white count, 13,000. Roentgenographic examination of gastro-intestinal tract showed hypermotility and slight irregularity at ileocecal valve.

First Operation.—Exploratory laparotomy; biopsy. Considerable free fluid. Large mass occupied right lower quadrant and extended into pelvis, composed of adherent coils of intestine and edematous mesentery with enlarged nodes. Wick to control hemorrhage.

Pathologic Report.—Chronic productive lymphadenitis.

No improvement. Symptoms persisted. No gain in weight. Irregularity of bowel habit developed. Now has diarrhea, eight to ten movements daily.

Second Operation.—Resection of cecum and terminal ileum. Ileocolostomy. Inflamed loop of ileum found extending for 14 to 15 inches proximal to ileocecal junction. Terminal inch less involved. Mesentery thickened and contained some hyperplastic nodes. Excess of straw-colored fluid present. Wall of terminal ileum thickened to three-sixteenths of an inch, shading off into normal bowel above. Resection of involved ileum carried out with ileocolostomy.

Pathologic Report.—Thirteen inches of ileum submitted, "coiled up." Coiled segment forms hard indurated inflammatory mass with thick bands of adhesions to contiguous loops. There are many enlarged lymph nodes. On opening the lumen decreases in caliber about eight inches from proximal end so that only tip of small finger can pass. Mucosa of narrowed part is coated by yellowish-brown necrotic pseudomembrane. Mesen-

teric aspect of lumen shows several sinus tracts ending blindly in the mesentery. Microscopic examination shows edema, polymorphonuclear infiltration, and inflammatory exudate. In other places thickening by dense fibrous tissue with minimal cellular reaction. *Diagnosis*.—Acute regional ileitis.

Culture of mesenteric node removed at first operation—negative. Culture of abdominal fluid four days after second operation—*B. coli*. Culture of resected specimen—negative. Expired two days after operation of shock and peritonitis.

CASE VI.—B. I. H., No. 17082. January 13, 1933. Male, aged 20. Complaint—intermittent draining sinus in right lower quadrant. This followed appendectomy with drainage at another hospital. The pathologic report was obtained. *Diagnosis*.—Chronic appendicitis. *Laboratory Data*.—Blood, serology and stools negative. *Roentgenologic Examination*.—Gastro-intestinal series revealed irregularity of cecum and narrowing and fixity of terminal ileum.

First Operation.—Several fistulous tracts about the ileocecal valve were closed, and an ileostomy performed. Slow but complete healing.

Reëntry 16½ months later because of repeated attacks of abdominal cramps and diarrhea alternating with constipation. Occasional fever.

Physical Findings.—Diffuse right lower quadrant tenderness on rectal examination. White count, 10,500; stools, negative.

Roentgenologic Examination of gastro-intestinal series essentially the same as previously. *Preoperative Diagnosis*.—Regional ileitis.

Second Operation.—Ileocecal resection. End-to-side ascending ileocolostomy. Terminal ten inches of ileum thickened, congested and adherent. The cecum was not involved. Convalescence not remarkable except for some wound sepsis and diarrhea.

Reëntry eight weeks later for residual abscess. Ileostomy and drainage. In the course of the next eight months several further procedures were required before the ileostomy sinus and obstructive symptoms finally subsided. For the past 18 months he has been free from symptoms. Lately an inguinal hernia has been repaired. Recent gastro-intestinal roentgenographic study reveals no evidence of obstruction or residual inflammatory disease.

Pathologic Report.—Twelve inch loop of bowel consisting of terminal ileum and small portion of cecum. Mesenteric attachment considerably thickened in the distal part of ileum. Roughened granular areas on serosa of terminal five inches of ileum on anti-mesenteric surface. Cecum not thickened. Fistulous tract present from cecum extending into lumen of ileum. Fistulous opening surrounded by polypoid and swollen mucous membrane. Lumen of ileum very much narrowed. Mucosa reveals numerous polypoid projections. Fibrin and purulent exudate fills folds and extends in streak-like fashion over mucosa. Section through ileocecal region shows numerous small circumscribed abscesses. Microscopic examination shows extreme congestion, inflammation, exudate and polymorphonuclear infiltration. Occasional giant cells are seen. *Bacteriology*.—Guinea-pig negative for tuberculosis. Smear shows streptococcus. No culture. *Diagnosis*.—Regional ileitis.

CASE VII.—B. I. H., No. 17559. February 27, 1933. Female, aged 14. Complaint—abdominal pain of eight weeks' duration. Intermittent in both lower quadrants, worse on right. Anorexia, nausea and vomiting on one occasion.

Physical Findings.—Firm, slightly tender, sausage shaped mass in right lower quadrant. *Laboratory Data*.—Hemoglobin, 80 per cent; red blood cells, 4,400,000; white count, 13,200; stool, liquid brown. Guaiac, 4+. *Roentgenographic Examination*.—Gastro-intestinal series: ileum markedly dilated, atonic and fixed. *Preoperative Diagnosis*.—Regional ileitis.

Operation.—Ileocecal resection. Lateral ileocolostomy ascending. Ileostomy. Free fluid with flecks of fibrin. Eight to ten inches of terminal ileum involved. Cecum and appendix, which was non-adherent, free of involvement. Closure without drainage. Excellent convalescence. Follow up 17 months later: Well, no complaints. Occasional

intestinal gurgling, usually at night. *Bacteriologic Report*.—Cultures from the peritoneal fluid, lymph nodes, ulcerative areas and advancing border of the lesion all grew streptococci in Barger's brain broth.

Pathologic Report.—Non-specific granuloma of ileum with ulceration and edema. Regional ileitis.

CASE VIII.—B. I. H., No. 19648. September 1, 1933. Male, aged 56. Complaint—abdominal pain before and after meals, of eight months' duration. Epigastric and right upper quadrant. Anorexia, nausea, vomiting and weakness. Loss of weight, 20 pounds in five months. Constipation, one month.

Physical Findings.—Firm, irregular orange size movable mass to right of umbilicus. Marked emphysema of lungs. Arteriosclerosis. *Laboratory Data*.—Hemoglobin, 60 per cent; red blood cells, 4,000,000; white count, 10,400; stool, liquid yellow. Guaiac, 2+. No mucus. *Roentgenologic Examination*.—Preoperative. There is a crescentic pressure defect on terminal ileum. Barium enema. Entire colon well outlined and regular. Ileocecal valve not patent.

First Operation.—Drainage ileocecal abscess. Ileostomy. Free fluid. Large inflammatory mass in region of cecum. Appendix and cecum appeared normal. Terminal ileum composing mass, thickened and engorged. Mesentery edematous. Abscess in center of inflammatory mass containing one ounce of creamy pus, drained. Convalescence fair. Urinary retention. Attacks of cramps and low distention. Second stage three and a half weeks later.

Second Operation.—Ileocecal exteriorization (Mikulicz). An ileal fistula to appendix and numerous adhesions encountered. No involvement of large bowel. Cecum and eight inches of terminal ileum exteriorized.

Mass resected on ninth postoperative day. Developed bronchopneumonia and repeated attacks simulating pulmonary infarction. Abdomen soft. Satisfactory fecal discharge from ileum. Grew progressively worse. Died three weeks following second operation. Autopsy not obtained. *Bacteriologic Report*.—After two days abscess shows *B. coli* on culture. After two days peritoneal fluid negative.

CASE IX.—B. I. H., No. 21119. January 19, 1934. Female, aged 27. Complaint—midabdominal pain and diarrhea. Colicky pain began 21 months ago, at first related to umbilical region. Later also in right lower quadrant. Nausea. Vomiting and loss of weight. Diarrhea for one year. Appendectomy three months after onset without relief.

Physical Findings.—Marked loss of weights. Lower abdominal distention. Tenderness and doughy resistance in right lower quadrant. Marked neurologic changes including nystagmus, increased tendon reflexes, ankle clonus and disturbed thermal sensitivity. *Laboratory Data*.—Hemoglobin, 70 per cent; red blood cells, 3,600,000; white count, 8000; stools, foul, liquid, gray-black. *Roentgenographic Examination*.—Preoperative. Spasm of ileum. Sigmoid appeared irregular and narrowed. Barium enema not tolerated.

Operation.—Ileocolostomy ascending. Cecum and large bowel normal except for adhesions between sigmoid. In exploration a very small cavity filled with granulation tissue but no pus was opened (ileosigmoid fistula?). Over one foot of terminal ileum was dilated and indurated, the mesentery thickened and containing hyperplastic nodes. Palpation of ileocecal valve revealed polypoid masses projecting into cecum. Attempts at mobilization followed by brisk hemorrhage; therefore anastomosis done as first stage of two stage resection. Incision closed without drainage. *Course*.—Rapidly fatal with all signs of a generalized peritonitis.

Comment.—It seems possible that a fistula not recognized preoperatively by roentgenography or at operation may have been opened causing peritonitis. Another possibility is the activation of a latent infection by opening a chronic abscess cavity. Drainage of the cavity with ileostomy above the involved segment would have been the proper surgical procedure.

CASE X.—B. I. H., No. 21412. February 14, 1934. Female, aged 29. Complaint—diarrhea of eight months' duration. Upper abdominal pain at onset but for two months cramp-like across lower abdomen. Appendectomy three years ago.

Physical Findings.—Loss of weight. Tenderness and resistance over entire right side of abdomen. *Laboratory Data.*—Hemoglobin, 55 per cent; red blood cells, 3,000,000; white count, 7000; stool, brown, loose formed. *Roentgenographic Examination.*—Pre-operative. No characteristic findings. Distended loops of bowel that appeared to be small intestine.

Operation.—Ileocecal resection. Lateral ileocolostomy ascending. Ileostomy. Small intestine dilated. Terminal eight inches of ileum thickened and inflamed, involvement apparently including the cecum. Mesentery indurated and swollen, containing hyperplastic nodes. Convalescence satisfactory aside from temporary postoperative shock. The patient has remained well.

Pathologic Report.—The specimen presents the typical appearance of non-specific ulcerative enteritis involving the terminal ileum. Numerous sinuses run from the ileum to the cecum and also blindly into the mesentery but the mucosa of the cecum shows no evidence of involvement. *Diagnosis.*—Regional ileitis.

CASE XI.—B. I. H., No. 25204. December 29, 1934. Male, aged 21. Complaint—colicky abdominal pain, diarrhea and constipation. For four years had constipation alternating with diarrhea. Cramp-like pain across lower abdomen for seven months. Loss of 14 pounds in weight last two months.

Physical Findings.—Moderate abdominal distention, visible peristalsis, fulness, resistance and tenderness in right lower quadrant of abdomen. *Roentgenographic Examination.*—Preoperative. Flat film revealed poorly defined mass filling right lower quadrant. *Laboratory Data.*—Hemoglobin, 70 per cent; red blood cells, 4,400,000; white count, not made; stools, guaiac strongly positive.

Operation.—Ileocecal resection. Ileocolostomy ascending. Ileostomy. Ileum much thickened and dilated for distance of about nine and one-half inches covered with fibrin. Small amount of fluid present in abdomen. Lumen of ileum narrowed in involved portion. Terminal ileum and part of cecum resected. Kerr end-to-end anastomosis and ileostomy performed. Convalescence excellent except for one grossly bloody stool on eleventh postoperative day. Patient has remained well.

Pathologic Report.—Twenty inches of terminal ileum and portion of cecum including appendix. Hyperplastic process begins 14 inches proximal to ileocecal valve where there is apparent obstruction. Proximal to this ileum greatly dilated, wall of bowel thickened due to edema of mucosa and submucosa. Mucosa of involved segment ulcerated with numerous superficial irregular ulcers. Process ends sharply at both ends. Deep erosions present all along mesenteric line, worse at proximal end, where there is a purse-string-like obstruction. Microscopic examination shows edema, inflammatory exudate and ulceration of involved bowel. *Diagnosis.*—Regional ileitis with ulceration. *Bacteriologic Findings.*—Guinea pig killed February 28, 1935. Negative for tuberculosis. No other organisms cultured.

SUMMARY

The term "regional ileitis" has been applied to a localized, non-specific enteritis of the terminal ileum.

A high incidence of the lesion is found among Hebrews.

Characteristically it affects young adults.

It is a well defined clinical entity, having a suggestive history that is corroborated by the physical examination and laboratory findings.

It is progressive in character with a tendency to develop partial intestinal obstruction, internal or external fistulae, and abscesses.

The treatment is surgical.

The preferable operative attack is by a one stage resection in uncomplicated cases.

Multiple stage operations are frequently indicated when abscesses or fistulae exist.

The surgical mortality is high, due to the large number of complicated cases encountered and the virulence of the underlying infection.

Recurrence has not occurred in the cases resected.

I wish to express my thanks to Drs. D. F. Jones, Carl Bearse, and R. H. Smithwick for permission to use cases from their private records.

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DISCUSSION.—DR. HORACE BINNEY (Boston, Mass.).—My interest in this subject is rather recent. I have had only two personal cases, both in young adults. A diagnosis was not made preoperatively in one, but was made before the second stage in the other.

The first case was one involving the lower ileum and small portion of the cecum with an abscess encountered at exploration for what we supposed was tuberculosis, and in spite of that abscess I was able to do a temporary first stage ileocolostomy, anastomosing the ileum to the transverse colon. About nine months later a fistula developed where the abscess was, but in spite of the fistula I was able to do a resection, and the patient has done very well.

In the second case a fistula was also present, but I was able to do a resection and end-to-end anastomosis. The patient was well at the end of six months.

Regional ileitis is an interesting surgical condition because of the variety of its manifestations and the apparent mystery as to cause. Also on account of its bizarre behavior in some cases, *e.g.*, cases in fairly early stage and involving several inches of the ileum, operated on under diagnosis of acute or subacute appendicitis, may go for years without further trouble simply with the removal of a chronic appendix. Again, removal of a segment of diseased bowel with adequate margins of healthy tissue may be followed quite quickly by recurrence in another portion of the ileum. Such a case is reported by Homans.

As to diagnosis, I agree that the early stages are so closely simulated by appendicitis that the true diagnosis is probably impossible preoperatively.

In the stages of ulceration, obstruction and tumor formation, or fistula externally, if one is looking for this condition the diagnosis should be frequently made. The blood in the stools, if present, is occult rather than the free blood of other forms of ulceration. The obstruction is slow in development and partial. The tumor is of slow growth which should differentiate this condition from most other forms of neoplasm: possibly not in the case of actinomycosis which, however, is very rare. Both the ulceration and fistula types may suggest tuberculosis, but the bacilli will be lacking from the stools. Doubtless in the future the diagnosis will be made much more often than in the past.

In advanced cases in poor risks, through age or other factors, ileocolostomy alone may be enough to restore the patient's health. Possibly, roentgen ray treatment may prove useful. Ileostomy alone would not seem to me of much value.

Doctor Mixter mentions severe hemorrhage as one of the dangers in attempting resection. It would seem that this procedure should, therefore, be avoided in the early stages, when hyperemia is marked, and that a preliminary exclusion by ileocolostomy would be safer, before resection is undertaken.

To clear up our knowledge of the subject, there is certainly need of more critical study by pathologists and of a much more close follow up of the so called subacute appendicitis cases which apparently are occurring frequently in our hospitals, some of which may well be early stages of this malady.

DR. EDWIN BEER (New York, N. Y.).—This interesting paper calls attention to a condition which has been overlooked apparently by pathologists and clinicians. Time alone will tell how frequently it occurs. In studying diverticulitis of the colon some 32 years ago, another condition which had been overlooked, I found in the literature only 18 reported cases. Ten years later, in studying diverticulitis of the bladder, I found the same situation obtained; there were only 10 or 12 reported cases which had been recognized and treated. Everybody now recognizes both these conditions as rather frequent occurrences, and I wonder whether regional ileitis will show similar frequency of occurrence. I am inclined to think that the condition is much more frequent than we realize and frequently goes, unrecognized. Many of these cases masquerade as appendicitis, and a few years ago such a case presented itself to me with a fecal fistula, having been operated upon for appendicitis, which was followed by an intestinal fistula, and then reoperated on for closure of the fistula. There was a persistent fecal fistula when the patient was seen by me, and ileocecal resection cured the condition and showed in the lumen of the ileum a chronic, non-specific ulceration.

As most of the speakers have said, many of these cases look like subacute appendicitis or chronic appendicitis and occasionally may show a narrowing of the lower lumen, as seen in Doctor Lee's presentation. Many cases present a mass in the right iliac fossa, which suggests either the above type of appendicitis or ileocecal tuberculosis. Following removal of the appendix, development of a fecal fistula or a slowly healing wound often suggests tuberculosis, though there is no evidence of tuberculosis in the removed appendix. Some of these cases of chronic fistulization are undoubtedly ileitis, and unless one has a chance to revise the wound the original surgeon fails to correct his primary impression.

In addition to external fistulization, many of these cases form a fistula between loops of bowel, and one of the series which I have seen was operated on for appendicitis and came to me with a large abscess in the abdominal wall. Subsequently the patient developed a fistula between the ileum and sigmoid, as well as a large retroperitoneal abscess which perforated into the left ureter.

It is essential in all these cases to recognize the condition early and resect, preferably ileocecal resection of the bowel, for untreated most of these cases go slowly down hill and are chronic invalids, many of them, as I said, masquerading as chronic intestinal tuberculosis.

DR. WALTER E. LEE (Philadelphia, Pa.).—We present a case of terminal or regional ileitis with the object of calling attention to the fact that this condition has been recognized in Philadelphia, and that, strange as it may seem, the underlying factors of race and youth which Doctor Mixter and Doctor Beer have emphasized are not confined to the cities of Boston and New York.

CASE REPORT

A Jewish multipara, 28 years of age, came to the gastro-intestinal clinic of the Graduate Hospital of the University of Pennsylvania in September, 1933, complaining of diarrhea of three months' duration and lower abdominal pain. The lesion was not diagnosed at that time and although she did not attend the clinic regularly, when she was admitted to the hospital one year later she had lost 46 pounds. There had been no long remission of symptoms during this interval of a year, and the tendency toward diarrhea and vague lower abdominal pain recurred rather frequently. About two months previous to admission her symptoms became aggravated and there was more severe pain in the region of the umbilicus and the lower right quadrant, associated with increased peristalsis and at times vomiting. The attacks suggested partial bowel obstruction. About this time there began an evening rise of her temperature to 101° F., and night sweats became a frequent complaint. The diagnosis of regional ileitis involving the terminal ileum was based upon the following:

(1) A long history of intermittent attacks of pain in the lower abdomen and lower right quadrant. There was mucous diarrhea but without tenesmus.

(2) Tenderness and muscle guarding in the lower right quadrant associated with a movable, palpable mass corresponding to the position of the terminal ileum.

(3) A persistent string sign in the terminal ileum, in the radiographic films.

(4) Absence of any clinical or radiographic evidence of tuberculosis, and the absence of signs of tuberculosis or any other type of intrinsic lesion in the cecum.

We performed a two stage operation because of an unfortunate experience following a one stage operation in the first case which we had encountered two years previously and did not recognize. At the first operation a laparotomy was performed through a lower right rectus incision and it was found that the terminal ileum and ileocecal valve were fixed and could not be delivered. About 16 to 17 cm. of the terminal ileum were covered by a fibrosed stenotic exudate and the glistening sheen of the wall, was absent. The walls were greatly thickened and rigid, feeling somewhat like a garden hose. Proxi-

mal to this region for a distance of seven cm. there was a more acute reaction in the serosa, the vessels being engorged and the fibrosed stenotic exudate merging gradually into a plastic exudate. Still further on, beginning at a distance of 24 cm. from the ileocecal junction, the diseased segment quite abruptly merged into normal appearing bowel. The mesentery of the distal 24 cm. of the ileum was thickened and boggy, and there were several enlarged lymph nodes in the base of the mesentery near the ileocecal junction. The presenting surface of the cecum and ascending colon did not appear or feel to be involved, but in the appendiceal region the cecum was tightly fused to the ileum by a well organized fibrotic membrane. The appendix was not visible nor could it be palpated in spite of a careful search. There was no evidence of fistula formation. While manipulating the bowel about two to three cc. of cream colored pus escaped from the base of the mesentery where it was adherent to the cecum, a culture of which was reported as containing, *B. proteus*. Because of the free pus it was deemed unwise to do more than a short circuiting anastomosis between the terminal ileum and the transverse colon. Convalescence from this first stage was uneventful.

At the second operation, after an interval of 16 days, we found no important change in the gross pathology seen at the first operation other than a few fine fibrous adhesions at the site of our previous operative field. At this stage the ileum was transected about eight cm. distal to the anastomosis and the proximal open end was inverted. The transverse colon was then transected about the same distance from the anastomosis and its open end inverted, following which the terminal ileum, appendix, cecum, ascending colon and a portion of the transverse colon were excised. The abdomen was closed without drainage. An uneventful convalescence followed. About six months later she had gained 34 pounds and was having two or three normal bowel movements daily and had returned to her household duties.

A follow up study with a barium enema at this time showed that the ileocolostomy was functioning properly.

DR. EMIL GOETSCH (Brooklyn, N. Y.).—I have had one experience recently with regional ileitis. This was a few months ago, before I had become at all familiar with this disease. Since I had an opportunity to study this condition and to operate for it, I became interested and had an opportunity to review Doctor Krohn's series of cases which were reported from the Mt. Sinai Hospital in New York City.

I thoroughly agree with the statement of Doctor Mixter concerning the great difficulty in handling the mesentery which so often is enormously thickened, very fragile and extremely vascular. In addition in these cases, as in mine, there was a large segment of small bowel firmly adherent and bound up in one large mass in the right lower part of the abdomen. I should like to emphasize the very extensive nature of the operation which must be seriously considered particularly in the patient who is often not in the best of condition. Consequently it might be well, as was pointed out in Doctor Krohn's paper, to adopt the two stage operation, namely an ileocolostomy as the first stage and then after a period possibly of even several months, resection of the diseased small bowel in the second stage. This would allow for some subsidence of the inflammation and the edema, and the ultimate operative results might be better.

As you see, the mortality in the series here reported was over 33½ per cent, which in a way seems very high. It would seem that after ileocolostomy in these cases obstruction might occur following contraction in the large amount of diseased adherent small bowel in the region of the terminal ileum, but strikingly this is not the case. In spite of the extensive fibrosis, inequalities in the caliber of the lumen, strictures and dilatations and even perforations, obstruction is not common.

In my case, the primary resection was rather well borne, but the patient died a few days after operation from general asthenia. I have felt that this fatal outcome might have been avoided had I done a two stage operation. I make this suggestion in general in the hope that the rather high mortality of primary resection may be reduced.

DR. HAROLD BRUNN (San Francisco, Calif.).—Crohn and his co-workers have done a real service in describing an entity which passed under various names and more or less defied classification. A group of us reported three cases soon after Crohn's paper appeared and since that time we have had two more cases.

The first case was that of a young lady who had been operated upon for appendicitis. A mass was found in the center of which was an abscess between the cecum and the ileum. The appendix, however, was quite normal. This mass was hard and fibrous and was drained. The patient made a good recovery and was discharged. During this interval we were fortunate to read Crohn's paper, and later when the patient developed signs of obstruction we recognized the case as belonging to this group. A resection was satisfactorily performed, and the patient recovered.

Our most interesting case was that of a young medical student, 24 years of age, who had had cramp-like pains in his abdomen from the time he was 11 years of age. His health, however, was fairly good for many years except that he was always thin and anemic in appearance. His present illness started in July, 1932, when he had continuous attacks of abdominal cramps, nausea and vomiting. At this time a diagnosis of pyloric spasm was made with etiology undetermined. In December, 1933, he reentered the hospital with abdominal cramps and a loss of 20 pounds during the preceding five months. His symptoms now were so severe that he was incapacitated. Roentgenography showed the jejunum to have four large dilatations with constrictions between them.

The patient was operated upon and the bowel removed and a side-to-side anastomosis made, but the patient died.

It was because of this case involving the jejunum that we felt the name regional ileitis did not apply and therefore considered changing the name to making it more inclusive and suggested chronic cicatrizing enteritis as a more descriptive term. However, regional ileitis seems to be accepted by the profession and will no doubt keep its place in the literature in spite of the fact that it is not entirely descriptive.

I was interested in the observation made that this disease appears to be more frequent among Hebrews. Of the five cases we have had all but one occurred in the Jewish race.

DR. EMMET RIXFORD (San Francisco, Calif.).—I suspect that regional ileitis or enteritis is perhaps more common than we ordinarily think. Most of the cases described by Doctor Mixter are chronic cases. Acute cases are not uncommon, and I have had the experience of operating upon a few of them under the diagnosis of appendicitis. In a recent instance in the person of a young physician: Leukocytes, 15,000; slight tenderness in region of appendix; slight fever; mouth temperature, 100°; pulse, 90. On operation the lower two and one-half or three inches of the ileum was seen to be engorged, in active peristalsis, red, swollen and covered with an exudate. The appendix seemed quite innocent but was removed for bacteriologic examination. Some enlargement of the mesenteric lymph nodes. Prompt recovery. There has been no recurrence in the past eight years.

In 1894 I was a very young man, young in surgery. One of my classmates who was much more of a student than I had a copy of Reginald Heber Fitz's paper on appendicitis, as well as Talamon's article. He therefore knew much more about appendicitis than I did. He was suddenly seized with acute abdominal pain, with localized tenderness, and made up his mind from his reading that he had acute appendicitis. It was before the days of the leukocyte count. I could not dispute his diagnosis. He said, "I must be operated upon." I demurred, whereupon he said, "If I die I wish you to perform an autopsy, and if you find that I could have been saved by operation, as a friend of mine you see to it that it is put upon my gravestone, 'Robert J., died a martyr of conservative surgery.'" The best that I could do under the circumstances was to go to my old preceptor, Dr. Levi Cooper Lane. Being a very wise man Doctor Lane said, "Do not operate but call Dr. Clinton Cushing." Cushing said, "Are you sure it is not typhoid fever?" He thought best however to open the abdomen whereupon it was evident that the lower foot or more of the ileum was in violent peristalsis, mesenteric nodes greatly enlarged. One of these nodes was removed for microscopic examination and nothing further was done. Patient went through a very stormy session with typical typhoid fever. I mention this case not merely for the dramatic story (patient finally got well) but to call attention to the fact that typhoid fever has been so nearly eliminated by our public health propaganda that we do not have enough cases these days to properly teach our students. Possibly some more modern student will operate for appendicitis in acute typhoid ileitis.

DR. CHARLES G. MIXTER (Boston, Mass).—I wish to express my thanks for this liberal discussion. There are two things I do want to speak of. The first is the question of etiology. It is obscure, and bacteriologically we have only a suggestion thus far to follow.

As far as the appendix goes, I believe that certainly not all cases can be traced to any appendiceal involvement, because we have had those cases in which the lesion was inspected at a relatively early date in which the appendix was apparently not involved at all. Furthermore, we have seen no case in which the mucosal evidence was such as to lead us to consider it a primary cause.

The sequence of operative procedure, I think, is extremely interesting to consider because although our mortality has been high, our high percentage occurred in complicated cases. I believe that there are a certain number of cases that are spontaneously arrested and resolve. I have not included them in this list, but we have seen two such cases at the operating table that have apparently later subsided spontaneously.

On the other hand, we have seen a very considerable number of cases that have progressed from a simple primary lesion without demonstrable fistulae or abscesses, that progress following a stage procedure. They form abscesses and fistulae later, and the secondary operation is definitely more hazardous. Furthermore, the inflammatory reaction has not appreciably subsided by the side tracking procedure and there still is an edematous, engorged and inflamed mesentery which bleeds freely and causes you as much difficulty as it would have had originally. Furthermore the risks of fistulae and abscess formation are added.

NON-SPECIFIC GRANULOMA OF ILEOCECAL REGION

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SINCE the appearance of Tietze's¹ report in 1920 upon "Inflammatory Tumors of the Large Intestine," there has been a growing interest in this pathologic condition and consequently an increasing amount of attention paid to the subject by pathologists and surgeons.

Although Dalziel,² in England, called attention in 1913 to an inflammatory condition which he termed "chronic interstitial enteritis," involving parts of both small and large intestine, there appears to have been no other publication in the English language until 1923 when Moschowitz and Wilensky³ of New York reported on "Non-Specific Granuloma of the Intestine." Since then in America an increasing interest has been shown, and comprehensive reports were made by Mock⁴ (1931), Crohn, Ginzburg and Oppenheimer⁵ (1932), and Ginzburg and Oppenheimer⁶ (1933). In these articles the clinical similarity of "non-specific granuloma" to other conditions, notably hypertrophic tuberculosis, was emphasized, and the pathology, symptomatology and clinical appearances fully described. The importance of the subject, due to the difficulties in diagnosis, and lack of uniformity in methods of treatment, has led to the publication by many authors of personal case reports, chiefly of conditions involving the lower end of the ileum, and using the terms "terminal" or "regional ileitis" as suggested by Crohn, Ginzburg and Oppenheimer. The latter authors considered the condition affecting the terminal ileum and ileocecal region to be a pathologic entity. Homans,⁷ who reported two cases in 1933, takes issue with them on this point. In his discussion of the pathology, he points out the identity of the pathologic lesion in the small intestine with granuloma of the various parts of the large intestine but admits that "regional ileitis" should be considered a clinical entity. Certainly the rather striking—although variable—characteristics of the disease in this region differentiate it from that in other portions of the bowel and the tendency to so group these cases is reasonable. The relatively large number of reported cases in the past few years, of lesions in the lower ileum or ileocecal region, supports this view.

A personal experience with two cases during the past two years has led the writer to a study of the reports, in this country and England, upon cases involving the lower ileum or ileocecal region. The purpose of this article is to present the clinical findings, diagnostic difficulties and results of treatment of this group of cases. This report is chiefly concerned with disease of the lower ileum and ileocecal region, of which there have been collected 24 from the literature, to which the writer's two personal cases are added,

making a group of 26 cases (Table I). In a few of the included cases the disease was more generalized.

Etiology.—In this series the youngest patient was five years old, the oldest, 64. The largest number by decades was between 20 and 30 years, 26 per cent. (5 to 10, 3 cases; 11 to 15, 1 case; 16 to 20, 4 cases; 21 to 25, 3 cases; 26 to 30, 4 cases; 31 to 35, 1 case; 36 to 40, 1 case; 41 to 45, 2 cases; 46 to 50, 2 cases; 51 to 55, 1 case; 56 to 60, 1 case; 61 to 65, 1 case; 2 ages not stated).

As to predisposing causes, there appears to be no constant factor in the way of previous disease, habit or circumstance of life bearing upon the condition of the gastro-intestinal tract. A possible exception exists in the history of our two cases, in both of which a suspicion of tuberculosis of the nodes at the hilum, and in one of concurrent mesenteric and spinal involvement. This point will be discussed later in the article.

Bacteriology.—Repeated attempts to demonstrate specific organisms by different pathologists have uniformly failed. In a few reported cases streptococci were found, as was the case in both of ours.

Pathology.—In only a few of the cases were full pathologic reports given. Those adequately described agree closely, both in gross appearance and microscopic detail, with the description given by Ginzburg and Oppenheimer. This is a concise summary of the process and is worth quoting here. "The persistence of infection or inability of the intestine to overcome it leads to a series of reparative and destructive processes, resulting in the formation of either hypertrophic peri-intestinal masses or extensive intramural hypertrophic ulcerative and stenosing lesions or a combination of both." The microscope shows "various stages of acute or chronic inflammation with infiltration by lymphocytes, polymorphonuclear leukocytes, plasma cells and mast cells, with varying degrees of fibroblastic proliferation, and often degenerative changes. Giant cells are common, probably due to particles of vegetable matter entrapped in ulcers. These may form nodules which, when present in the serous layer, are difficult to distinguish from tubercles. These 'vegetable' cells may be responsible for hyperplastic fibrosis. To this should be added the occasional presence of abscess, due to perforation of an ulcer, and doubtless explaining the development of fistulae between adjacent portions of bowel, or into other organs or even through the abdominal wall. If the perforation is into the abdominal cavity, a peritoneal abscess results." According to Ginzburg and Oppenheimer, in "regional ileitis" the lesion is most marked at the ileocecal valve and diminishes proximally, rarely extending higher than 12 to 15 inches: the process starts with ulceration along the mesenteric side of the bowel; in the second stage there is perforation or extreme proliferation in the submucosa, the third stage being a conversion of the terminal ileum into a thickened, rigid, hose-like tube. Linear ulcerations along the mesenteric border are common, while near the cecum the mucosa is atrophic with papillary excrescences, especially near the ileocecal valve.

Clinical Picture.—With such a variety of pathologic conditions in the different stages of the process, it follows that the symptoms will vary greatly in different cases. Ginzburg and Oppenheimer describe four clinical types, as follows:

(1) *Symptoms Simulating Appendicitis.*—The majority of cases fall under this head. While the picture is not clear cut, in general the symptoms point definitely to the right lower quadrant, beginning with localized pain, with more or less spasm and tenderness. If accompanied with fever, nausea or vomiting and leukocytosis the picture naturally suggests acute appendicitis. The symptoms may be mild and recurrent; however, diarrhea or constipation may occur and in many cases the picture is of so called chronic appendicitis. In our collected series the diagnosis was appendicitis, or the appendix had previously been removed, in 14 cases (53.8 per cent).

At operation the lower ileum is found to be soggy and edematous with large nodes in the mesentery, or in some cases abscess is already present. Drainage may be followed by fistula, or primary healing may occur with secondary breaking down, weeks or months later (Ginzburg and Oppenheimer). This was the case in both of our personal cases, and in 19 per cent of the series.

In a recent case at the Boston City Hospital, a boy of nine years, operated upon by Dr. N. C. Browder (not included in the series), there was bloody fluid in the abdomen, the appendix was normal, the lower ileum showed hemorrhagic areas varying from one to five inches in length—and enlarged mesenteric nodes were found. Such a picture suggests typhoid but there was a leukocytosis and the patient made a prompt recovery after operation (appendectomy). Possibly it represents ileitis in an early stage.

(2) *Symptoms of Ulcerative Colitis.*—This type is rather uncommon and shows diarrhea, loss of weight and strength, secondary anemia and mild colicky pains. Of the series, only two seem to fit into this group at the time the lesion was recognized. Both of Homans' cases gave a previous history of diarrhea, but had progressed to the stage of partial obstruction and palpable tumor when seen by him. The stools show occult blood rather than free blood of ulcerative colitis.

(3) *Symptoms of Chronic Partial Obstruction.*—Ginzburg and Oppenheimer found this the most common type, sometimes preceded by the first or second. Cramps, borborygmi and visible peristalsis are prominent symptoms often lasting from one to three years. Sooner or later a mass develops, leading to the diagnosis of hyperplastic tuberculosis or neoplasm. Eleven of the 26 cases were of this type (42 per cent).

(4) *Chronic Intractable Fistulae.*—Both of our cases developed a fistula, one after appendectomy and recurring after attempted closure; the second followed drainage of abscess found at the first operation. In the series, four (15 per cent) were of this group.

TABLE I

Reporter	Year	Sex	Age	Duration Symptoms sev. wks.	Diagnosis	Physical Examination	Appendec- tomy	Ilcoecolos- tomy	Rescction	Pathologic Report	Results
1. Dalziel ¹²	1913				Subacute ob- struction		Exploration			Chronic in- terstitial enteritis	Death
2. Moschowitz and Wilensky ³	1923	M.	23	2 yrs.	1919 chronic diarrhea. 1922 acute obstruction		1 yr. previ- ously	1919	Cecum, 1919. Ileum, 1920	Granuloma ?	Fistula, 1919. Perforation, 1922. Recovery
3. Moschowitz and Wilensky ³	1923	M.	33	8 days	Subacute typhlitis	Tenderness r. l. q.	2½ yrs. before	1920	Cecum	Granuloma ?	Well 1 yr. later
4. Moschowitz and Wilensky ³	1923	F.	44	3 wks.	Tumor	Tenderness r. l. q.	—	+	+	Granuloma ?	Well 1 yr. later
5. Friedenwald ¹¹	1932	M.	50	?	Obstruction	Tumor of cecum	—	+	—	—	Recovery
6. Friedenwald ¹¹	1932	F.	52	?	Appendicitis		+	—	—	—	Not relieved by appendectomy
7. Hirschman ¹⁵	1932	M.	18	9 yrs.	Ulcerative colitis	Loss of weight	+	—	12 in. of thick- ened ileum	Granuloma	
8. Gordon ¹²	1933	F.	49	3 yrs. chronic appendicitis. 1 yr. later tu- mor appeared			+	—	Ilcoecal region 1 yr. later	Granuloma	Well 9 yrs. later.
9. Hanford ¹⁶	1933	F.	30	?	Tumor (cramps)		—	—	Terminal ileum	Granuloma	Symptoms contin- ued
10. Jannsen ¹⁷	1933	F.	21	2 wks.	Acute appen- dicitis		+	—	—	?	Fistula developed
11. Eggers ¹³	1933	?	57	1 yr.	Obstruction		—	Roentgen- ray treatment	—	—	Well 2½ yrs. later
12. Eggers ¹³	1933	?	64	35 yrs.	Chronic ap- pendicitis	Mass r. l. q.	—	+	Explor. 1 mo. later. Mass much smaller, not removed	—	Well 9 mos. later
13. Peterson ¹⁴	1933	?	?	?	Chronic chole- cystitis, 7 mos. later obstruc- tion, ? malign- ant, roent- gen-ray therapy		+	6 mos. later well for 5 yrs., then abscess drained		—	Sinus persists

GRANULOMA OF ILEOCECAL REGION

14. Rocky ¹⁰	1933	M.	5	2 yrs.	Acute appendicitis	Temperature. Tender spasm r. l. q. Distention	+	Normal appendix. Ileum thickened	-	-	Convalescence normal
15. Rocky ¹⁰	1933	F.	9	2 yrs.	Acute appendicitis	Tenderness r. l. q.	-	+ Term. ileum thickened	-	-	-
16. Rocky ¹⁰	1933	M.	11	1 wk.	Acute appendicitis	Tenderness r. l. q.	-	+ Term. ileum thickened	-	-	-
17. Rocky ¹⁰	1933	F.	19	3 days	Acute appendicitis	Slight spasm r. l. q.	-	+ Term. ileum thickened	-	-	-
18. Homans ⁷	1933	M.	30	6 yrs.	Tb. ?	Roentgen-ray. Narrow ileum. Loss of weight Mass r. l. q.	+	Terminal ileum thickened	-	-	-
19. Homans ⁷	1933	F.	26	2 yrs.	Tb. ?	Roentgen-ray. ileum narrowed Tender spasm r. l. q.	+	-	-	-	-
20. Clute ³	1933	M.	40	1 yr.	Ileitis ?	Weight loss. Roentgen-ray, constriction at cecum	+	-	-	-	-
21. Clute ³	1933	M.	41	3 yrs.	Perforation ? Chronic obstruction	Tender 1 l. q.	+	-	-	-	-
22. Phillips ¹³	1934	M.	25	5 yrs.	Obstruction	Roentgen-ray 6 yrs. before	+	-	-	-	-
23. Bell ¹⁹	1934	F.	28	4 yrs.	Obstruction lower ileum	Roentgen-ray positive	+	-	-	-	-
24. Holman ²⁰	1934	M.	6	24 hrs.	Appendicitis	Discharging sinus of abdomen Mass at cecum	+	-	-	-	-
25. Binney	1935	M.	19	3 wks.	Postoperative fistula	Chronic obstruction. ? Tb. cecum	+	-	-	-	-
26. Binney	1935	F.	19	1 yr.	Chronic obstruction. ? Tb. cecum	Mass at cecum	+	-	-	-	-

Diagnosis.—Even a superficial glance at the published case reports affords sufficient explanation for failure to make a correct diagnosis on history and physical findings. Naturally few of the earlier observers knew anything of the pathology of this disease: and often the diagnosis was unsuspected until resection for supposed tuberculosis or neoplasm was carried out, and the true diagnosis was made by the microscope.

In a few instances during the past three or four years the diagnosis has been suspected by the surgeon (Clute,⁸ Homans) with the aid of a roentgenologic examination. The close similarity to other lesions makes an exact diagnosis exceedingly difficult if not impossible. Tuberculosis of the hyperplastic type probably is more often confused with non-specific granuloma in this region than other conditions, such as carcinoma, sarcoma, or syphilis leading to tumor formation. The use of the roentgen ray may be precluded in cases of the acute appendicitis type or where vomiting is present. Its value, however, in selected cases is well brought out by Kantor⁹ who, in 1934, reported on a study from the roentgenologic standpoint, of six cases operated upon by Dr. A. A. Berg. In these, his findings were:

- (1) A constant filling defect in the lower ileum.
- (2) In 50 per cent the small intestine showed abnormal shape of the loops proximal to the filling defect.
- (3) Actual obstruction in some cases (here 30 per cent) causing retention of the barium meal in the ileum nine or more hours after administration and dilatation of proximal loops.
- (4) The "string sign," a thin, irregular linear shadow suggesting a cotton string in appearance and extending more or less continuously through the entire filling defect and ending at the ileocecal valve. This is the most striking filling defect and was present in four of the six cases. This, however, does not exclude tuberculosis, syphilis or sarcoma.

He emphasizes the importance of frequent films, every hour or so, after administration, to avoid missing the passage of the barium meal through the constricted portion. In his series, the diagnosis was made before operation in one case only. The possibility of preoperative diagnosis will depend upon the stage in which the patient is seen, as indicated by the four clinical picture groups outlined above. In the first group, when acute appendicitis may be closely simulated, the roentgen ray will usually be inapplicable on account of nausea and vomiting. Here the diagnosis can be made only after the disease is exposed at operation. In the other groups, the roentgenologic technic suggested by Kantor may help to suggest the strong possibility of regional ileitis, especially in cases which present a history of repeated attacks over a period too long for the relatively short course of tuberculosis or malignant disease. Where the disease is of the chronic ulcerative type, the absence of free blood in the stools, as emphasized by Homans, is of importance.

Prognosis.—Of this collected series of 26 cases, but one patient died following operation. This was Dalziel's case, in which exploration only was performed on account of a very extensive process producing signs of chronic

obstruction. A study of the group resembling appendicitis shows that many of those in which appendectomy only is done will have further symptoms. Crohn, Ginzburg and Oppenheimer found that 50 per cent of the cases observed by them had been previously subjected to appendectomy. In the collected series here studied, eight cases had had no further operative treatment at the time of reporting. Four of these reported by Rockey¹⁰ have not been followed long enough since operation to be considered cured. Of the remaining four, one (Friedenwald¹¹) was unrelieved and symptoms were continuing at the end of two years. The other three, (Moschowitz and Wilensky, Gordon,¹² Phillips¹³) showed recurrence of symptoms in from five months to two years. From this series, therefore, one cannot deduce that appendectomy alone is ever followed by permanent cure, nor is there any suggestion from a study of the pathology that such a result can be expected. The other 18 cases of the series, which had had previous appendectomy without permanent relief, were subjected to the following operations and showed results, as follows:

Drainage of Abscess.—One case (Clute). Improved.

Ileocolostomy.—(Side-tracking.) Three cases (Friedenwald, two), (Clute, one). Recovery.

Resection and Ileocolostomy.—Fourteen cases, in one of which the late result is not known. In two (Moschowitz and Peterson¹⁴) fistulae developed. In one (Homans) the patient improved, and in another (Homans) there was recurrence in ileum. In the remaining ten cases "recovery" or "well" after periods from six months to two and one-half years, was noted.

Summing up the results in the whole series, one may say that the mortality in this disease is low (less than 4 per cent) considering that operations of considerable gravity may be necessary to effect a cure: that appendectomy probably influences the course of the disease but little; that ileocolostomy alone may be followed by permanent relief in some cases, but as yet this is sub judice and that radical removal of the diseased intestine gives the best chance of permanent cure (71 per cent in this series).

Treatment.—The fact that many of the cases in this series had been given more or less prolonged medical treatment without lasting benefit indicates that surgery is necessary to effect a cure in all cases. This conclusion must be qualified, however, by the statement that Eggers found one of his cases benefited by roentgen ray therapy following a side-tracking operation only. Peterson also had a similar experience, the improvement lasting for five years. Both cases later came to further operation so that how much importance can be given to the roentgen ray therapy rather than the ileocolostomy is a question. It is probably fair to say that in selected relatively early cases, this method of treatment should be given further trial. As to the precise operative procedure to be chosen, it is apparent that although ileocolostomy alone had been followed by temporary benefit, it cannot be expected to effect a cure in any large proportion of cases. In cases compli-

cated by abscess or fistula, or in patients whose general condition does not warrant radical treatment, it may prove of great temporary value. This certainly was true in our second case.

Resection of the diseased bowel has been more effective in producing a cure than any other procedure, and must be regarded as the operation of choice in the large majority of cases. While a side-to-side anastomosis, either previously or at the time of resection, has been employed in most cases, in our first case we obtained a good result by an end-to-end anastomosis between the dilated end of the ileum and the ascending colon.

CASE REPORTS

CASE I.—Joseph H., aged 19, was admitted to the Boston City Hospital, First Surgical Service, January 25, 1934, complaining of a tenderness in the region of an appendectomy scar.

Previous History.—Whooping cough as a child. Tonsillectomy at eleven years of age; otherwise healthy, good appetite, bowels regular. About five years ago had a sudden attack of abdominal pain, below the umbilicus, somewhat relieved after vomiting. Next day was admitted to the hospital, where symptoms recurred to a milder degree. There had been a similar mild attack six months before. Temperature, 100°; white blood cells, 7,200; polymorphonuclears, 82 per cent.

Physical Examination.—Negative except for tenderness in right lower quadrant and several small "olive-like" masses palpable in this region on deep pressure. No spasm. Symptoms subsided and patient was discharged four days later with diagnosis of subacute appendicitis and "tabes mesenterica."

Five weeks later had an attack of right lower quadrant pain, with vomiting. Pain was of colicky nature—every 15 to 20 minutes—lasting one to two minutes. After two days, pain less severe. After a week readmitted. Tender over appendix region. Next day appendectomy under local anesthesia. Some free fluid present. Appendix retrocecal and bound down by adhesions to cecum in proximal half. Wound closed. Kahn negative. Pathologic report: Healed appendicitis. Normal convalescence. Discharged on eleventh day.

About a month after the appendectomy he began to have cramp-like pains in the lower abdomen, worse in right lower quadrant. During attacks he felt a lump in this region which became tender. Usually he felt better after bowels moved. Bowels fairly regular. Pain aggravated by cathartics. As attacks increased in severity, he was again admitted on the medical service for observation (September, 1931). At this time he appeared poorly nourished. P. M. temperature 100° F. Slight tenderness and spasm noted in right lower quadrant. Nauseated at times. Examination of chest showed diminished resonance at left apex: no râles. Roentgenologic examination showed moderate infiltration of left apical region. Sputum negative for tuberculosis. As some rigidity of spine was noticed, roentgenograms were taken which were reported as tuberculosis of eleventh and twelfth dorsal vertebrae. Stools negative for T. B. and for occult blood. Barium enema negative, but "cecum is tender." At this time he had lost about 15 pounds in weight. Was discharged to a tuberculosis sanitarium in October, 1931, where he received palliative treatment, rest in bed and heliotherapy. He improved, gaining in weight, finally resuming an active life and was discharged "arrested" in February, 1933.

At time of admission to our service (January, 1934), he stated that for past three years occasional sharp pains in region of scar, lasting a few minutes, have continued. Gained weight in past two years, good appetite and bowels regular. Recently noticed a swelling in region of scar, painful and tender for past two days. Examination showed a

reddened, fluctuant mass in this region, two inches in diameter, very tender on pressure. Temperature, 99° F. Urine negative. The abscess was incised and drained. Discharged two days later to out patient department. Two weeks later the discharge became fecal and he was readmitted February 15, 1934. At this time impaired resonance of left lung apex and slight lower dorsal kyphosis noted. Mass in region of scar with fistula in center. Diagnosis.—Tuberculosis (?), regional ileitis (?).

Cultures from fistula showed *B. Coli*, diphtheroids, *Staphylococcus aureus* and *Streptococcus viridans*.

As the fistula showed no tendency to close, he reëntered the hospital and on April 1, 1934, under spinal anesthesia, tract of fistula excised down to the cecum and cecal opening closed, but it soon reopened. Patient again left the hospital with the fistula discharging, but was readmitted October 29, 1934, a second fistula having developed. Painful attacks apparently less severe during past year. The diagnosis was now probable tuberculosis of the cecum and radical operation was advised and accepted. On November 7, 1934, under gas-oxygen anesthesia, the fistulae were packed with gauze and an incision six inches in length, avoiding the fistulae, was made and cecum developed by dividing adhesions. In the process the cecum was opened, the wall being very thin in places, elsewhere much thickened, especially about the ileocecal valve. Cecum packed with gauze and lower ileum freed, found pale in color, markedly distended and wall moderately thickened. The condition was recognized by my assistant, Dr. Joseph Tartakoff, as regional, (terminal) ileitis. Resection of the ileocecal region, five inches of colon and two inches of the ileum, was carried out, and owing to the dilated condition of the ileum, end-to-end anastomosis in two layers performed. Owing to the bowel having been opened, a cigarette wick was placed into the pelvis and wound closed about it. Patient made a good recovery, drain being removed on the seventh day. Discharged on the fifteenth day. Bowels moving normally. The patient has had no further trouble to date.

Pathologic Report.—Joseph H., S-34-3838. *Gross.*—Specimen consists of two masses of tissue, one measuring 4 by 2 by 1 cm., covered on one narrow surface by skin which has several ulcerated areas 2-3 Mm. in diameter. Subcutaneous tissue is reddish-gray and firm. Cut surface shows sinus tract through subcutaneous tissue to ulcerated area in skin. Second mass of tissue measures 14 by 7 by 2 cm. One surface is covered with markedly, injected mucous membrane, from which several pedunculated polyps 1-2 cm. in diameter project. Several ulcerated areas in mucous membrane. Walls markedly thickened. Edges have been cauterized.

Microscopic.—*Ileum.* Mucosa.—Considerable portion of mucosa replaced by vascular granulation tissue densely infiltrated with lymphocytes, plasma cells and eosinophiles. Elsewhere the intact mucosa shows some increased connective tissue containing numerous lymphocytes, plasma cells and eosinophiles. Submucosa.—Increased connective tissue beneath granulation tissue described above. This area of connective tissue and adjacent normal submucosa densely infiltrated with the same types of cells as the mucosa. Muscularis.—Numerous lymphocytes, plasma cells and eosinophiles. Serosa.—Increased connective tissue. Focal collections of lymphocytes, plasma cells and eosinophiles. Section from most proximal portion of ileum shows same process as described above but less marked in degree.

Cecum.—Mucosa.—Villous-like projections in places. In one area mucosa replaced by granulation tissue thickly infiltrated with lymphocytes and plasma cells. Lymph follicles hyperplastic. Submucosa.—Increased amount of dense fibrous tissue. Foci of many lymphocytes, plasma cells and eosinophiles. Occasional dilated gland filled with mucus. Muscularis.—Some perivascular collections of lymphocytes, plasma cells and a few eosinophiles. Serosa.—Dense fibrous tissue with focal collections of plasma cells, lymphocytes and occasional eosinophiles.

CASE 2.—Gertrude H., an 18 year old school girl, was admitted to the hospital on the Medical Service November 28, 1933, with the following history. The *Family History*

revealed that a sister, now deceased, had been under treatment for supposed pulmonary tuberculosis.*

Past History.—Tonsillectomy at 4 years. Otitis media at eight years. Six years ago was run down and had a cough all winter but no night sweats or hemoptysis. Four years ago, after an attack of pain in back, chills, fever and nausea, the cough returned. Admitted to hospital where fluid was found in left chest posteriorly. Tapped and 1,000 cc. fluid aspirated. Kahn negative. Roentgenologic Report.—“Thickened pleura at left base.” Six weeks later was discharged with diagnosis of tubercular pleurisy to a sanitarium where hilum tuberculosis was diagnosed. An intradermal test was positive. After a stay of ten months she had gained 16 pounds and was discharged for home care. Two years ago she was operated on at another hospital for ischiorectal abscess. She appears to have been in fair health until six months ago when noticed a small, tender lump in the right lower quadrant and was readmitted to the same hospital. The diagnosis was acute appendicitis and operation performed under ether. On exposing the appendix a mass found involving four inches of terminal ileum. Bowel much thickened and edematous. No free fluid. Appendix removed. Wound closed. Normal convalescence. Discharged on eighteenth day with diagnosis of intestinal tuberculosis.

Present Illness.—Four months ago again noticed the lump in right lower quadrant. It increased in size and became tender. She began to have attacks of sharp pain in this region and to lose weight. Occasional vomiting and lately, a dull pain, getting worse.

Physical Examination.—Temperature, normal; blood pressure, 120/80. A hard, rounded, slightly tender mass, 8 by 8 cm., in right lower quadrant: not adherent to abdominal wall. Can be felt bimanually through the rectum. Urine negative. Kahn negative. Hemoglobin, 65 per cent; white blood cells, 11,000. Tuberculin test positive. Stool negative for tuberculosis. Roentgenologic Examination.—Barium enema shows cecum displaced upwards by mass. Meal showed “cecum and lower ileum irritable and spastic.” Moderate delay at ileocecal region but ileum empty after 24 hours.

Progress Note.—In spite of ultraviolet, high vitamin and supportive treatment for some weeks, during which there was no nausea or vomiting and bowels acted normally, the mass continued to increase and painful attacks persisted, with occasional fever. Operation advised with intention of doing a side-tracking operation, supposedly for tuberculosis of cecum. Transferred to First Surgical Service.

On February 10, 1934, under spinal anesthesia supplemented by gas-oxygen, a six

* The sister's history became known to us after this article was written. There is a striking similarity in the two cases, *viz.*, an illness covering a period of several years, beginning with supposed pulmonary tuberculosis and diagnosed as such by roentgen ray, then fistula or ischiorectal abscess, and finally abdominal symptoms and discovery of mass in region of cecum. The sister's history was, briefly, as follows: At the age of 13 was seen at the out patient department of the Boston City Hospital where fever and dulness in left apex were noted, and roentgenogram showed peribronchial infiltration. Mass in region of cecum noted. Was advised to have home treatment. This was continued for five years when, an extensive fistula in ano having developed, she was operated upon in another city. Several operations were performed during her twentieth year without accomplishing complete healing. During the next year she began to have cramp-like pains and some constipation and finally an acute attack with fever, pain, spasm, tenderness and a mass felt in right lower quadrant. Exploration revealed a tumor of ascending colon, attached to right kidney: considered inoperable, ileocolostomy performed. During the next year, pain and obstructive symptoms occurred off and on and finally in her twenty-second year resection was carried out. She died from shock 12 hours later. At the first operation the appendix was found only slightly thickened and congested. The specimen removed at the second operation was sent to Dr. F. B. Mallory, who found “chronic ulceration; no evidence of tuberculosis.”

inch right rectus incision made over the mass. Peritoncum found much thickened. Incision prolonged upward and peritoncum entered: mass adherent to abdominal wall, size of an orange. In attempting to free it on outer side, pus cavity entered. Yellowish necrotic material escaped, 4 or 5 cc. in amount, apparently tuberculous. Cavity packed. Incision carried around inner side of mass, lower ileum brought up and lateral anastomosis made with transverse colon, with two layers of chromic gut. Wound closed except for small drain into abscess pocket. Material from abscess sent to laboratory where guinea-pig inoculation proved negative. Culture showed mixed growth, including streptococci. Fair convalescence. Fecal discharge developed from sinus to abscess cavity. After six weeks sinus much smaller but still draining. Patient discharged after eight weeks.

After returning home the patient gradually improved in health and was free of painful attacks, bowels moving normally. During rest of 1934 and early months of 1935, in good health save for the discharging sinus. By this time our attention had been called to "regional ileitis" and our probable error in diagnosis realized. Accordingly, when the patient returned for examination early in April, 1935, it was felt that only removal of the ileocecal region would cure the condition. Operation was advised and accepted and the patient reentered the Boston City Hospital April 14, 1935. Two days later, under spinal and gas-oxygen anesthesia, the sinus was isolated. The ileocecal region exposed and about four inches of cecum and ascending colon removed, the ends of bowel closed without drainage. The patient made a good recovery and was discharged two and one-half weeks after operation. She has been well up to the present time.

Pathologic Report.—Gertude H. S-35-1107. *Gross.*—Specimen consists of lower ileum and cecum. Entire specimen 21 cm. long, of which 17 cm. is the ileum. Proximal 8 cm. of ileum are only slightly thickened. Mucosa thrown up into many transverse folds. Walls of remainder of ileum average 1 cm. in thickness. The mucosa is thrown up into many folds, is soft and edematous. Slight thickening of muscularis. The ileum within 3 cm. of ileocecal valve and most of cecum has a thick, fibrous, firm, stiff wall. The lumen in this portion is only 8 Mm. in diameter. About 1 cm. proximal to the ileocecal valve is the ostium of a fistula which goes through the wall of the ileum and continues for 1.5 cm., the wall of the latter consisting of fat and fibrous tissue and lined with grayish-red granulation tissue. Portion of cecum inferior to ileocecal valve has its lumen completely obliterated by the thick contracting ligneous fibrous wall. Marked injection of all the mucosa. Entire serosa moderately thickened, grayish-white and granular.

Microscopic.—*Proximal Ileum.*—Essentially negative save for hyperplasia of lymphoid tissue.

Distal Ileum: Mucosa.—In one area, mucosa is lacking, being replaced by granulation tissue densely infiltrated with lymphocytes and plasma cells. Remaining mucosa contains numerous lymphocytes, plasma cells and eosinophils. *Submucosa.*—Numerous lymph follicles, perivascular collections of lymphocytes and plasma cells and diffusely scattered cells of the same type as well as eosinophils. Connective tissue greatly increased resulting in marked thickening of this layer. *Muscularis.*—Perivascular collections of lymphocytes and plasma cells. *Serosa.*—Increased connective tissue. Scattered lymph follicles. Perivascular collections of lymphocytes and plasma cells. Several foreign body giant cells containing crystalline material.

Cecum.—Mucosa shows changes similar to those of the distal ileum. *Submucosa.*—Markedly thickened due to proliferation of connective tissue, formation of lymph follicles and infiltration with lymphocytes, plasma cells and some eosinophils. At one point, a focal collection of large mononuclears and two giant cells. *Muscularis.*—Infiltrated with a moderate number of lymphocytes and plasma cells. *Serosa.*—Increased amount of connective tissue containing both diffusely scattered and focal collections of lymphocytes and plasma cells.

Colon.—Negative.

SUMMARY AND CONCLUSIONS

(1) A study of 24 cases reported in the literature, with the addition of two personal cases, is presented.

(2) The present day knowledge as to etiology, pathology and clinical pictures is reviewed.

(3) The prognosis for life is favorable, the mortality in this series being 4 per cent. To effect a cure, radical surgery with or without roentgen ray therapy seems necessary.

(4) Resection of the diseased bowel, either preceded or accompanied by ileocolostomy, is the most effective treatment in the majority of cases.

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- ¹³ Phillips: *New England Jour. Med.*, vol. 211, p. 457, 1934.
- ¹⁴ Peterson: Discussion of Gordon, v. s.
- ¹⁵ Hirschman: Discussion of Crohn, *et al.*, v. s.
- ¹⁶ Hanford: Discussion of Gordon, v. s.
- ¹⁷ Jannsen: Discussion of Gordon, v. s.
- ¹⁸ Eggers: Discussion of Gordon, v. s.
- ¹⁹ Bell: *Calif. and West. Med.*, vol. 41, p. 239, 1934.
- ²⁰ Holman: Discussion of Bell, vol. 41, p. 239, 1934.

COLECTOMY FOR ADENOMATOSIS AND PSEUDOPOLYPOSIS

A REPORT OF FIVE ADDITIONAL CASES

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IN 1931, at the meeting of the American Surgical Association in San Francisco, I reported six cases in which total ablation of the large bowel and rectum had been done for either familial adenomatosis or complicated chronic ulcerative colitis which had destroyed the bowel functionally, leaving it a focus of infection besides producing other unpleasant sequelae.

To this report I now wish to add five cases which I have operated upon during the past three years, in three of which extirpation of the colon was done for the familial variety of adenomatosis, while in the other two the secondary indication of ulcerative colitis necessitated surgery.

In the two series, the entire colon and rectum was sacrificed in seven cases, while in four the whole colon was removed, leaving the rectum. In two of these cases the rectum was saved by a deliberately planned procedure with the idea of destroying the polypi and subsequently reestablishing the continuity of the gastro-intestinal tract by an anastomosis between the terminal ileum and the rectal stump. This was accomplished successfully in one case, but in the other case an operative mortality following the colectomy prevented the carrying out of the planned procedure.

In the other two cases in which operation was done for chronic ulcerative colitis, the rectum was not excised, but I assume that there is a strong possibility that this may be necessary at a subsequent stage, although at present the health of the two individuals is extremely good and they have resumed their usual occupations.

The question of saving the rectum and destroying the polypi, thus obviating the sacrifice of the sphincteric mechanism and the permanent use of an ileostomy, seems to be favorably answered for certain cases by the result not only in the case successfully treated by this method, but in the response to fulguration of the other case in which it was tried but which terminated fatally following the second stage of the operation.

Hitherto, I have felt that because of the possibility of malignancy developing in the disseminated adenomata, one should routinely employ the extremely radical procedure, and in the first six cases which I reported this was done. However, after observing the gratifying response to fulguration in the rectal stump, particularly after the fecal stream has been side-tracked, I feel certain that many of these cases may be treated by this alternative method, and successfully so. Of course, in the chronic ulcerative colitis variety where a "lead-pipe" colon, the result of long-standing inflammatory changes, is removed, there is no question of anastomosing the small bowel into

the rectal stump, and the ileostomy must be borne permanently. The question of whether the rectum is removed at a subsequent stage depends upon whatever complications develop such as perirectal abscesses, *etc.*

Indications and Pathology.—Most observers agree that in about 50 per cent of the cases of diffuse adenomatosis of the familial type, carcinoma develops if the lesion is left unremoved or undestroyed. Certainly, that there is a distinct relationship between cancer and benign diffuse adenomatosis, cannot be denied.

Cuthbert Dukes of St. Mark's Hospital, London, England, has an interesting and carefully compiled series of families in which several members in different generations have developed multiple polypi, and his paper on "The Hereditary Factor in Polyposis Intestini, or Multiple Adenomata," published in the April, 1930, issue of the Cancer Review, is a most instructive one. He points out first, that "these polypoid growths are composed of adenomatous proliferations of the intestinal mucosa"; second, that "they are the result of an inherited constitutional predisposition to epithelial tumors of the intestine"; third, that "the disease runs in certain families, being inherited as a Mendelian dominant"; and fourth, that "it almost invariably ends in cancer of the intestine."

Hitherto intestinal polypi have been described under many different terms, most frequently being designated as "multiple polyposis." Pathologically, one must distinguish between the congenital or disseminated type and the pseudopolyposis secondary to inflammatory ailments of the large bowel.

In studying the histopathology of adenomatosis and the relationship to malignancy some years ago, FitzGibbon and I, in tracing a series of cases from hyperplasia of the polypoid type of growth to malignant change, used much the same criteria as Wechselsmann, Schmieden, and others in studying not only the epithelial elements of the tumor, but the connective tissue framework and macroscopic appearances as well.

That polypi may be divided into three distinct groups, varying grossly and microscopically, is, I think, an easily reached conclusion. In Group 1, the epithelial elements are normal; the tumors appear as small nodules on the mucous membrane of the bowel sometimes as large in diameter as 2 cm. on gross section, and are invariably pedunculated. We do not believe that this Group 1 polyp has a tendency to become malignant, although the possibility must be admitted.

In the Group 2 polypi the changes in both the epithelial and connective tissue elements are quite pronounced and obvious. Not only does the epithelium fail to differentiate into normal mucosa, but the cells are elongated, arranged in single rows, and occasionally pushed into buds which project into the tubules or the connective tissue matrix. The nuclei are elongated likewise, and take stains deeply, giving to the proliferating tissue a darker color.

With continuation of the proliferation of the epithelial elements, a complementary response in the connective tissues of the muscular coats results in the formation of a pedicle which will be large or small according to the

rapidity of growth. Most likely this rate of development is an important factor in the sequence of changes from benignancy to malignancy. These polypi of Group 2 may attain great size and by the very action of the intestinal peristalsis be either pushed along the lumen of the bowel, producing an intussusception, or even be amputated from their stalks and extruded through the rectum. The carcinomata which develop from such polypi usually are the large pedunculated adenoid-like intraluminary growths which are of low grade malignancy as measured by Broders' index, whereas the polypi of Group 3 which represent but an accentuated form of Group 2 develop much more rapidly, become punched out, sessile, ulcerating carcinomata which invade the bowel toward its serosa rather than toward the lumen.

This is an important clinical point because it may be demonstrated that the rectal and colonic growths which project intraluminary are usually less malignant, and that the sessile, ulcerating, rapidly growing ones progress toward the serosa and therefore invade the adjacent lymphatics more quickly. The very fact that it is provable that polypi, either single or multiple, or widely disseminated in form, do metamorphose into malignancy, and further, that this malignancy occurs more frequently in that segment of the bowel in which polypi occur more frequently, namely, the lower sigmoid and rectum, influences one to accept them as etiologic factors in a high percentage of cancers of the colon and rectum. That it is impossible to state how high a percentage or defend the theory that all cancers of this location develop on polypi, is obvious, nevertheless, it is difficult to escape the conclusion that such a theory is most tenable generally.

The congenital type of polypoidosis manifests itself by the well-recognized symptomatology of profuse rectal hemorrhage, diarrhea, and anemia in young people, and can be easily differentiated from the pseudopolyposis of inflammatory lesions, although the latter sometime even develop malignancy as Bargen showed in reporting 25 cases of carcinoma which had developed in the presence of polypi secondary to inflammatory lesions in a series of 1,100 cases of ulcerative colitis.

This latter type—pseudopolyposis—constitutes the second very definite indication for removal of the colon when that organ becomes not only functionless, but distinctly dangerous as a source of absorption.

In the one instance—adenomatosis—the patient is faced not only with a debilitating disease which during exacerbations greatly undermines health, but with the certainty that at least one-half of these cases die of cancer.

In the other type of lesion, a fulminating acute disease finally is improved by therapy which includes an ileostomy because of the nature of the underlying pathology and if there result unfortunate sequelae which produce arthritis or other debilitating conditions, ample reason for undertaking a series of grave operative procedures is provided.

The appended five cases illustrate not only the pathologic types for which operation was done, but the complications which may occur during and following operation, and furnish also additional proof that by the use of ful-

guration for the destruction of polypi in the lower segment of the bowel, it is possible to extirpate those portions of the colon which may not be so treated, and thus in addition to removing the menace of malignancy, save nature's splendid sphincteric apparatus and obviate the necessity of permanent abdominal stoma.

CASE REPORTS

CASE 7.—A. D., female, aged 19, first examined October, 1932. Family History: Father, one sister, three brothers, living and well, and no significant bowel history in any member of the family. Menstrual history is negative; menses began at 13, three days' duration, no discomfort, usual 28-day type. Past History: No serious illnesses—had the usual diseases of childhood.

Chief Complaint.—Bleeding from the bowel which began when the patient was five years of age. At that time it was discovered that she had rectal polypi which tended to

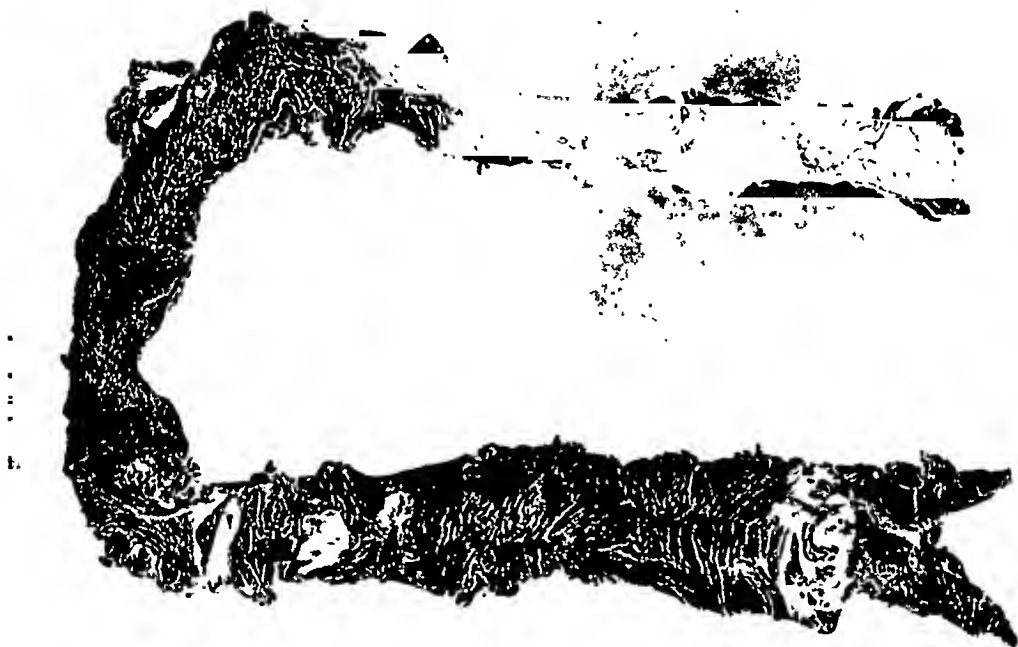


FIG. 1.—Case 7.—Entire colon and rectum showing multiple pedunculated polypi and numerous smaller ones throughout the entire course of the bowel. There are several very large polypi in the cecum.

bleed and protrude, and which were excised on nine different occasions by her local physician without any change in her symptomatology. She suffered from constipation, Grade 3, which was relieved by daily administration of mineral oil. She frequently had low abdominal cramps, and more frequently passed bright red blood, and between such attacks often noticed blood on the stools.

Her general health was not impaired and she has maintained her average weight. Roentgenologic examination following barium enema showed multiple polypi involving the entire colon. On October 14, 1932, she was operated upon through a McBurney incision, a single barreled ileostomy being made. Multiple polypi could be felt in the cecum. Her recovery following the ileostomy was satisfactory and she gained weight and strength and had no complaint except for an occasional bloody rectal discharge. When she returned in March of 1933, six months later, for the colectomy, she weighed 133 pounds which was an increase of 10 pounds over her usual weight, and her general examination was negative. The rectal examination still showed many polypi extending up as far as the finger or proctoscope could reach.

The blood count was: erythrocytes, 4,000,000; hemoglobin, 76 per cent; and leuko-

cytes, 8,200 with 62 per cent polymorphonuclear neutrophils, all of which were segmented. There were 33 per cent lymphocytes; 3 per cent monocytes; and 2 per cent eosinophiles. The urine was negative. Roentgenologic examination of the colon was not done.

At the time of the second stage of the operation the following was done: long left Lennander incision. Colon was mobilized easily from right to left, and a subtotal colectomy was done, removing the organ down to the lower third of the sigmoid (Fig. 1). The omentum was saved, the raw surfaces were easily peritonealized. It was determined to do a combined perineo-abdominal resection, removing the lower segment of the bowel and rectum at a subsequent stage.

Following this second stage, the patient's immediate postoperative condition was satisfactory. She received a routine transfusion of 500 cc. of citrated blood on the first postoperative day. The maximum temperature was 100° the first seven days postoperatively, while the pulse did not exceed 100. The convalescence was uneventful and she was dismissed from the hospital on the fourteenth day, her wounds being healed and her general strength sufficient to allow her to walk out of the hospital.

Three months later she returned for a check up, saying that she had been doing unusually well until the past three weeks when she began to feel general malaise, the ileostomy did not function satisfactorily over this period, and she suffered generalized abdominal pains with occasional nausea and vomiting. This was relieved by treatment and she remained free of pain for a while, but the ileostomy did not function as well as previously. A general check up on her showed the blood count to be: erythrocytes, 4,590,000; hemoglobin, 76 per cent; and leukocytes, 7,000. The urine was negative. The general physical examination was negative; the examination of the ileostomy showed a reduction in caliber of the opening due to scar tissue contraction, and it seemed to me that this was the source of the patient's obstructive symptoms.

The ileostomy was dilated manually, the scar tissue excised around the opening, and she was dismissed from the hospital on the third day with instructions to continue dilation of the ileostomy with her finger.

After an interval of three months she returned for the third stage of the operation, namely, the combined perineo-abdominal resection of the rectum. Since her last visit it had been necessary to dilate the ileostomy daily and the cramps in the abdomen had continued at intervals of two or more weeks, at which times they would last from two to three days at a time. She had continued on liquids and soft diet, but with no abatement of the distress.

General examination at this time gave no evidence of any findings different from those of previous visits. After preliminary preparatory treatment over a period of five days, a combined perineo-abdominal resection was done. Her convalescence was uneventful. She remained in the hospital for 18 days, at the end of which time she was dismissed in good condition.

One year later the patient reported that for a period of ten months she had had the same generalized cramps in her abdomen which she had previously complained of, and which were still relieved by passages from the ileostomy. The attacks, however, had grown more frequent and the present illness had lasted two weeks. Some nausea and vomiting were associated with these attacks which had not been present during the others. When she returned, the examination was essentially negative, but the attacks were so definitely obstructive in type and had persisted over such a period of time that it was felt necessary to make an exploration of the abdomen. This was done through a long left rectus incision and an obstructing band in the jejunum was found. The bowel proximal to it was distended three to four times its normal size. This band was divided and the obstruction immediately relieved.

It was interesting to note that the abdomen was remarkably free from adhesions with the exception of the one very definite string-like band which accounted for the patient's obstruction.

The immediate postoperative course following this procedure was uneventful and smooth. There was immediate relief of all the previous discomfort and the ileostomy functioned without interruption. The patient was dismissed from the hospital on April 12, 1934. Since that time she has remained well, is back to normal weight and engages in her usual occupation.

Comment.—The unusual opportunity to explore this abdomen 12 months after the final operation—the combined perineo-abdominal resection which completed the total colectomy—revealed the almost complete absence of adhesions in the abdomen despite the extensive surgical procedures which had been undertaken in multiple stages. A single obstructing band was the sole

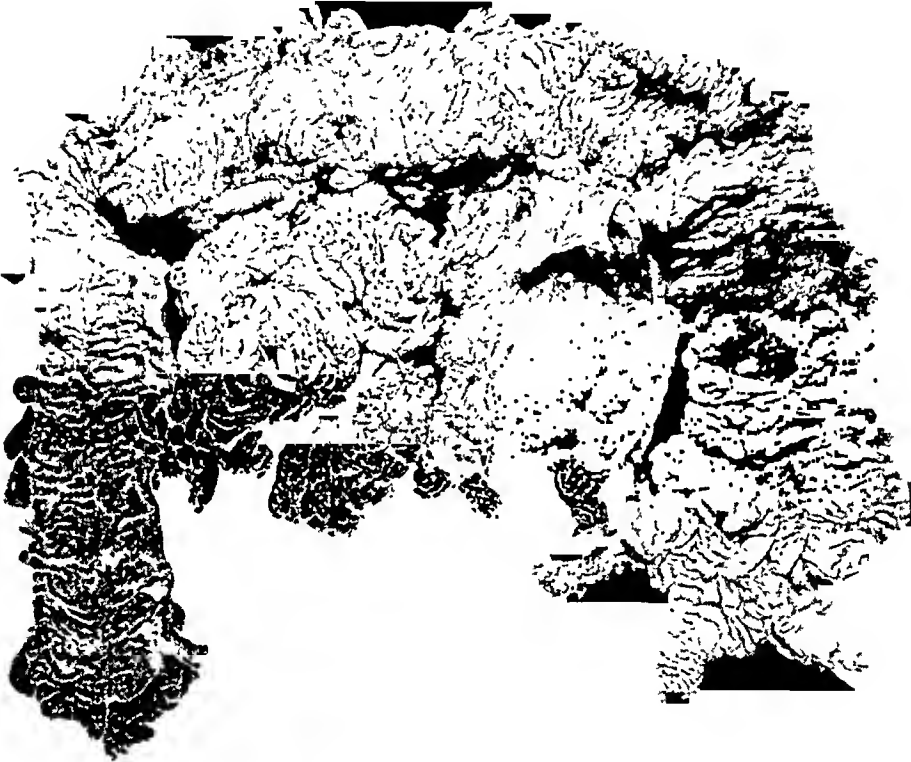


FIG. 2.—Case 8.—This picture shows the entire colon which was removed with the omentum. The rectum was preserved and in this case the continuity of the gastrointestinal tract was reestablished subsequently. The polypi are diffuse throughout the entire colon, but are small.

evidence of inflammatory reaction which had followed these operations. The rest of the peritoneal cavity appeared as though the large bowel were congenitally absent.

CASE 8.—Mrs. T. J. R., female, 32 years of age, married, whose past history is not unusual except for puerperal sepsis with her first child born in 1921. The family history is significant in that her mother died at the age of 32 with polyposis of the colon.

Patient was first examined on June 9, 1932, because of a complaint of severe headaches at the time of her menses, and irregularly occurring gaseous distention of the upper abdomen, relieved usually by soda. There was no quantitative food distress, no heart burns, no sour stomach. Her bowels were inclined to be loose and there had been one spell of diarrhea lasting several days at the onset of this discomfort several years ago, but no history of blood in the stool was obtained.

On examination patient appeared fairly well nourished and developed, 5 ft., 4 inches tall, and weighing 123 pounds. The systemic examination was essentially negative with the exception of bowel irregularity which on closer inquiry seemed to have a considerable bearing on the patient's major distress. Proctoscopic examination, however, showed multiple polypi in the rectum and rectosigmoid, while roentgenograms of the colon following barium enema revealed that these polypi extended throughout the large bowel, although more prominent in the left half. Surgery was recommended and on June 24, 1932, a single barreled ileostomy was made. Her recovery was uneventful and on October 7, 1932, subtotal colectomy was done, removing the large bowel down to the juncture of the middle and lower third of the sigmoid (Fig. 2). It was deliberately planned at this time, because the polypi were not so diffuse as had been seen in other cases, to attempt fulguration of the lower segment and if this was successful, to reestablish the continuity of the gastro-intestinal tract.

The patient's postoperative convalescence was uneventful and following fulguration she returned in September of 1933 when proctoscopic examination revealed that the entire rectum was clear of any polypi. On September 29, 1933, one of my former colleagues again operated upon her, doing a lateral anastomosis between the terminal ileum and the rectosigmoidal segment. She was dismissed on November 8, 1933, in excellent condition and her most recent report in February of 1935 states that her general health is excellent with no restriction in activity and that she quite easily performs her household duties, indulges in swimming and other sports without the slightest fatigue or discomfort. Her bowels have been restored to normal routine, without distress. Her weight is 123 pounds, which represents her optimum weight.

Comment.—The maneuvers carried out in this case, resulting in the ablation of the colon and the reestablishment of the continuity of the gastro-intestinal tract, represent the ideal surgical offensive in handling a case of diffuse adenomatosis. Certainly, to avoid a permanent stoma, where it may be done without fear of enhancing the chances of developing future malignancy, is greatly to be desired.

The deliberate plan in this case was undertaken because the majority of polypi were beyond the rectosigmoid and yet there was a sufficient number in the rectum to make us feel that unless fulguration rapidly destroyed them, the removal of this segment likewise was justified. The satisfactory disappearance of these tumors under this type of treatment was most gratifying and the final result distinctly satisfactory to both patient and surgeon.

I am convinced that this type of procedure is more applicable than I hitherto believed, and this opinion is buttressed by further experience in Case 10 where the polypi were so diffuse that no normal mucosa could be seen on proctoscopic examination prior to fulguration, but where likewise the response was immediate and most strikingly effective.

CASE 9.—J. D., adult male first examined in January, 1927, at which time he was found to have an extensively ulcerated rectum and secondary strictures suggestive of an advanced although rather localized, chronic, ulcerative colitis. There was an associated rectal incontinence and a secondary anemia, the hemoglobin being 60 per cent, erythrocytes, 3,460,000, and leukocytes, 15,000. The general debility was marked. His chief complaint was of a profuse rectal drainage.

The bowel history dated back to 1920 and was characterized by the irregularities of chronic ulcerative colitis, namely, frequent passages of blood and mucus day and night, varying from 10 to 20 in number and associated with abdominal cramps and generalized

tenderness. He had been treated over a period of seven years symptomatically until this examination and the proctoscopic findings indicated the type of underlying pathology.

On January 26, 1927, an exploration was done and it was found that there was definite ulceration in the lower sigmoid and that the colon above it was somewhat dilated. There was some exudate on the bowel and a colostomy was made at a point several inches above the involved segment. Following this he received the usual serum treatment followed by some vaccine, and had a very good year with marked reduction in his bowel movements and marked general improvement.

On February 18, 1930, he returned and it was found that the disease, as so frequently happens, had spread upward. I did a plastic operation on the colon and made the note that "the ulcerative process has involved the segment of bowel being used as a colostomy and the mucous membrane of this segment is quite thick and edematous. The bowel as far as the finger can reach is evidently involved and I think it will be necessary later to put the colostomy higher in the bowel, or do an ileostomy." On January 5, 1931, I did an ileostomy, making a note that there was a good deal of inflammation around the ileocecal region and suggesting that a colectomy in the future would be necessary.

He made an immediate recovery which was satisfactory and on April 3, 1931, I took out the colon around to the site of the colostomy. This operation was difficult and the specimen removed showed a diffuse ulceration, most marked in the cecum. The operative note is as follows: "An ileostomy and colostomy had been done on this man previously. There is ulcerative colitis that has caused strictures and abscesses. The abdomen is full of adhesions from the former peritonitis. The colon was densely adherent everywhere and I had to dig it out. The operation was extremely difficult. I had approached it through a long left rectus incision and found that where the former colostomy was made there was still a sinus with an abscess in the mesentery and a lot of small bowel adherent. Finally succeeded in getting the small bowel away without opening it and got the sigmoid up, divided it and sewed the end up without turning it in. There was very little peritonealization anywhere. The pelvis was drained with two Penrose drains with gauze, one split tube drain, one rubber tube drain and one strip of iodiform gauze. Think if the patient gets over the shock of the operation, chances of relief of symptoms are good except for the opportunity of developing high intestinal obstruction subsequently."

The patient had a stormy convalescence and was dismissed from the hospital at the end of a month. He continued to have a good deal of drainage from the lower loop and occasional reformation of perirectal abscesses. The original colostomy was a loop one and this gave him some trouble so that on January 19, 1934, a former colleague of mine did an anastomosis between the proximal and distal loops with a Murphy button, leaving him with a single barreled colostomy.

He has been comfortable since this last operation but apparently the adhesions which I predicted at the time of the colostomy have been forming and he has had several attacks of subacute obstruction. These have not necessitated another operation, but unquestionably he continually faces such a dilemma. He has been restored to occupation and at present is carrying on as usual.

Comment.—Clinically this patient has had several attacks of incomplete obstruction due to adhesions and in addition has still the lower segment of his bowel which harbors chronic ulcerative colitis. With the occasional development of a perirectal abscess, it is possible that focal infection may come from this later, and I think that it is reasonable to suppose that removal of this remaining segment may subsequently be necessary. He has returned to work, however, and is carrying on his usual duties despite these occasional intermittent interruptions.

CASE 10.—Mrs. M. C., aged 28, housewife, whose past history was irrelevant except for the present bowel complaint. Her family history is of interest in that one sister, 24 years old, has adenomatosis of the colon, demonstrated by roentgenologic and proctoscopic examination. One brother died at the age of 25, six days after an operation for the same lesion.

The present complaint is of diarrhea and abdominal cramps dating back eight or ten years, but becoming increasingly worse during the past year. She has bowel movements daily from one to two up to ten or 12, usually loose and frequently containing blood and mucus, but no tarry particles. There has been some soreness over the entire abdomen and particularly in the lower left side, for several years. There is no history of dyspepsia or upper abdominal distress.

Systemic history of the head and neck, cardiorespiratory, genito-urinary, and nervous systems was without significance. The patient is a well nourished young female 5 ft., 2 inches tall, weighing 122 pounds, whose blood pressure is 104/70, pulse 80, and temperature 98.6°. Head and neck show nothing unusual except for a small adenoma one centimeter in diameter in the upper left pole of the thyroid. There are no tremors of the tongue or extended fingers, and no eye changes. The lungs are clear throughout, the breasts are nulliparous in type, and contain no tumors or abnormalities. The heart is not enlarged, the rate being 80 with a regular rhythm. The abdominal examination is not unusual except that there is tenderness and rigidity Grade 2 in the lower left quadrant, and an easily palpable descending colon. Pelvic examination is negative.

Digital examination of the rectum reveals multiple polypi as far as the finger can extend and the proctoscopic examination shows these growths to cover the entire mucosal surface, and to vary in size from a split pea to 1.5 cm. in diameter. The routine blood examination shows: erythrocytes, 3,450,000; hemoglobin, 70 per cent; and leukocytes, 4,500. The urinalysis is negative except for a faint trace of albumin.

On July 5, 1934, a single barreled ileostomy was performed. The whole colon including the cecum was found on palpation to be filled with these polypoid tumors. The convalescence following this operation was without incidence and she was dismissed from the hospital on the fourteenth day to return home for an interval of rest and rehabilitation before the next stage.

Two months after her dismissal, she appeared greatly improved and had gained several pounds in weight. Proctoscopic examination was done and fulguration of the polypi in the rectum was undertaken with the idea that the rectum might be saved and that the reestablishment of the bowel's continuity as in Case 8 might be carried out.

On September 25, 1934, the patient underwent her first fulguration under transsacral procaine anesthesia and the polypi were found to be so thick that it did not seem a favorable case for this type of treatment. However, when she returned two months later, a great recession had taken place in the local process and a further fulguration was undertaken. Following this so much recession occurred that I felt if we could divide the lower colon, remove the large bowel, and thus side-track the fecal current completely and put the rectum at rest, we would have a better chance of accomplishing the proposed procedure.

On November 16, 1934, I removed the whole colon down to the juncture of the middle and lower thirds. It was difficult to turn in the rectal stump satisfactorily because fulguration had not been accomplished as high as the division of the bowel, however, I did get this turned in and covered with fat tags in a manner which I thought probably would be satisfactory. The removed specimen showed a very diffuse adenomatosis throughout the entire colon, more marked in the left half than in the sigmoidal region (Fig. 3).

Following operation a sharp reaction was noted in the first 24 hours, the pulse going to 120 and the temperature to 101°. The routine treatment of the administration of 500 cc. of citrated blood, and fluids given intravenously and by hypodermoclysis to 4,500 cc.

during the first 24 hours, was carried out. The urinary output was adequate. On the third day the temperature had risen to 103° and the pulse to 140. On the sixth day this elevation continued but the patient's general condition appeared better. The abdomen was distended 2 on a scale of 4, and drainage from the ileostomy was free. At this time it was felt that she had a peritonitis.

On the ninth day there was slight change, the leukocytes having attained a level of 31,500 with 88 per cent polymorphonuclear neutrophils, 11 per cent of which were non-segmented. The abdomen was less distended, however, and the patient was taking fluids by mouth without discomfort. The lungs were resonant throughout and the heart, except for the sharp increase in rate, was normal. On the twelfth day her general condition appeared improved—the wound was healed, the dermal sutures were removed, but there was edema low on both sides of the abdomen, the temperature was 104°, and the pulse 130.

Under local anesthesia, a small edematous, indurated area 5 cm. in diameter to the right of and below the lower extremity of the abdominal wound but apparently not associated with it, was incised and a considerable amount of serous, foul smelling, purulent

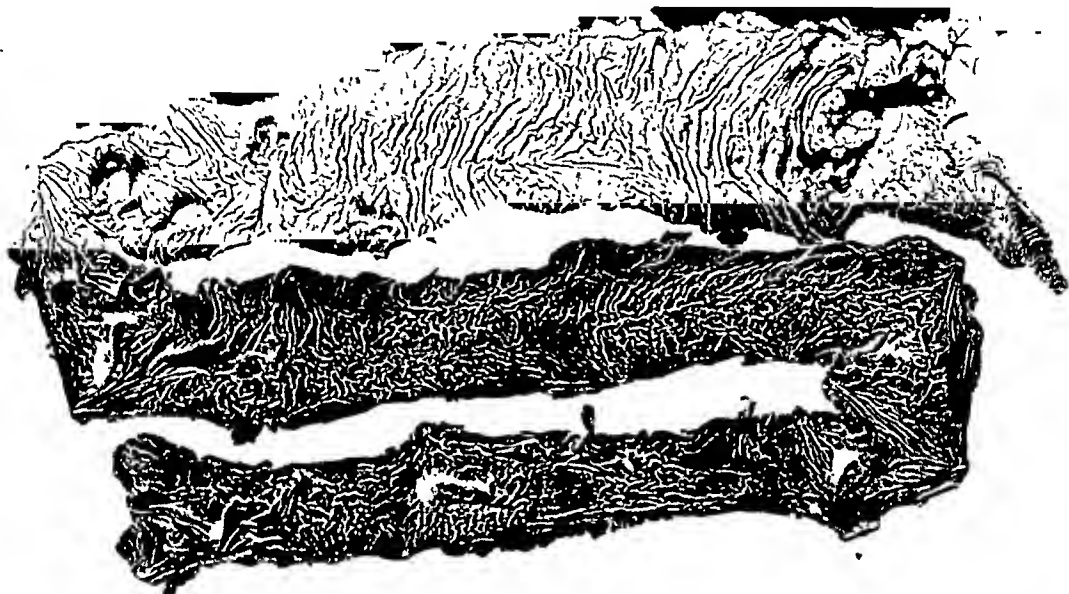


FIG. 3.—Case 10.—Subtotal colectomy was done nearly to the rectosigmoid juncture. This picture shows multiple polypi, some large pedunculated ones and numerous small ones. In the sigmoid and rectum the polypi were so diffuse that no normal mucosa could be seen.

material was liberated. Following this there was some decline in temperature and pulse, and the general condition seemed improved. Vaginal and rectal examinations again revealed no pelvic masses.

On the seventeenth postoperative day another complete examination was made which revealed the chest clear of any consolidations or pneumonic processes. The abdomen was distended 1 plus and there was a moderate amount of purulent drainage issuing from the stab wound at the lower end of the abdominal wound. The ileostomy was functioning adequately.

The general condition of the patient was considered improved and it was felt that she was combating successfully what had evidently been a pelvic peritonitis. At 5:00 o'clock in the afternoon of the eighteenth day the patient complained of severe epigastric pain for the first time, rapidly became cyanotic 3 on a scale of 4, and her radial pulse became imperceptible. The blood pressure fell to 44 millimeters of mercury systolic and 20 diastolic. It was felt that she had a pulmonary embolus. The usual supportive measures were without avail and the patient died within three hours after this attack. A postmortem examination was refused.

Comment.—Here, I feel, better judgment would have been exercised had I not departed from the customary routine of completing the fulguration before attempting the colectomy. The marked recession of the polypi in many of these cases following simple ileostomy, however, encouraged me in the belief that if the alvine discharges were side-tracked and the lower segment left free to be irrigated for a period and then to be fulgurated until it was clear of polypi, I could hasten the recovery.

Again, a technical difficulty presented itself in the handling of the stump because of the presence of great numbers of polypi. The development of the pelvic abscess and subsequently the pulmonary embolus may fairly, I think, be charged to these changes in procedure.

The astonishing disappearance of the polypi under fulguration was the outstanding point in this case to me and far surpassed any hope I had of such accomplishment. It urges more and more the utility of this method of clearing out a suitable segment for the implantation of the ileum and saving the normal sphinteric mechanism, while at the same time the patient is rid of the potential development of a colonic malignancy.

CASE 11.—B. S., male, 24 years of age, whose family history is as follows: father, mother and five sisters living: one of the latter has had chronic ulcerative colitis over the past ten years, during which time she has had a permanent ileostomy and subtotal colectomy. There are no other cases of chronic ulcerative colitis in the family.

Past History: Patient had a tonsillectomy for tonsillitis seven years ago. Present complaint began about that time and was characterized by frequent passages of blood and mucus, and liquid stools as many as 10 to 20 a day. This bowel irregularity was constant, harassing, and accompanied by generalized abdominal cramps. Shortly after onset, the patient became so greatly debilitated and weakened by his constant bowel drainage that he was unable to maintain his normal body weight.

A diagnosis of chronic ulcerative colitis was arrived at, based on proctoscopic evidence, roentgenologic examination of the colon with a barium enema, and cultures made from the ulcers in the rectum. The patient was given vaccine which produced little effect on the bowel lesion. One year after the onset, patient had an ileostomy made. Improvement followed this procedure but the drainage of blood and mucus from the bowel continued. In addition, he was beset by a severe arthritis which involved multiple joints and disabled him for weeks at a time. This malady usually manifested itself more intensely during the winter months and failed to respond to the symptomatic measures in conjunction with baking massage and vaccine therapy. For the past five years the patient has been a semi invalid and unable to perform any type of work. He was first seen by me on January 14, 1935, having been referred for consideration of a total colectomy. This procedure was contemplated primarily to be rid of a grossly and intensely involved colon which continued to debilitate the patient, rendering him an invalid and serving as a focus for his arthritis.

General examination revealed a man 5 ft., 6 inches tall, who weighed only 125 pounds and who appeared chronically ill. His teeth had been roentgenographed and showed no peri-apical infection, his tonsils had been removed, and the sinuses were normal. His heart and lungs were found to be normal. The abdomen was scaphoid and contained in its lower right quadrant an ileostomy. The surrounding skin was not excoriated. The left half of the colon was palpable and tender throughout. There were no abdominal masses present. Rectal examination was difficult and unsatisfactory because of a stricturing inside the anal sphincter, and some fissures which were so painful that only the little finger could be admitted. Proctoscopic examination was impossible, roentgenography of the

colon was not done for the same reasons. There was some slight limitation in the knees, ankles, elbows, and wrists, but no gross deformities and no increased local temperature. The last exacerbation of the arthritis had receded six weeks previously.

The blood count was: erythrocytes, 4,300,000; hemoglobin, 83 per cent; and leukocytes, 17,900 with 83 per cent polymorphonuclear neutrophils, 98 per cent of which were segmented; lymphocytes, 13 per cent; and monocytes, 4 per cent. The urine was negative. The temperature was normal and the pulse was 80.

Following a preliminary preparatory period of five days, during which time the patient was on a high caloric diet and an increased amount of fluids, colectomy was undertaken. His low midline incision was extended beyond the umbilicus through the left rectus muscle up to a point nearly opposite the tip of the ninth rib. The ileostomy had been made close to the cecum and this increased the difficulty of the colectomy which, however, was finally accomplished down to the rectosigmoid juncture in the usual manner. The omentum was saved.

The bowel was friable and jeopardized satisfactory closure of the stump. Precaution was taken against leakage by suturing the stump over and over and by wrapping it in iodoform gauze. He made a satisfactory convalescence, the temperature on the third



FIG. 4—Case 11.—Typically destroyed colon following long standing ulcerative colitis. Mucosa smooth, haustrations have disappeared, the colon is contracted and functionless.

day reached 102° and the pulse was 120. He had an immediate postoperative transfusion of 500 cc. of blood, and during the first three days fluids were administered intravenously and subcutaneously to an amount of 5,000 cc daily.

There was considerable purulent drainage from the pelvis which had been anticipated, but this gradually diminished, the drains were removed, and the patient was out of bed on the twenty-first day. Seven days later he was dismissed from the hospital. A recent letter states that he is feeling better than at any time during the past five years and that he has gained 12 pounds within the last month. He plans to return to work shortly after an absence of several years.

Comment.—Following ileostomy this patient presented the unusual complication of a "lead-pipe" colon harboring sufficient infection to produce multiple arthritis (Fig. 4). The experience in a former case in this series in which total colectomy was successfully undertaken with complete elimination of arthritis and the return of the patient to work, prompted similar advice to this individual, and the outcome has been equally as satisfactory as in Case 6.

TECHNIC OF COLECTOMY

Like most other operative procedures which remove portions of the colon for different pathologic reasons, total or subtotal colectomy is, I am convinced, best undertaken as a graded operation which may usually be best accomplished in three stages. These stages consist of: first, ileostomy; second, colectomy; and third, either removal of the rectum by a combined perineo-abdominal type of procedure, or anastomosis of the ileum to the rectum and closure at the same time or subsequently of the discharging ileostomy.

Ileostomy should invariably, I think, precede the other technical steps by a matter of weeks or months because of the serious disturbance of fluid balance which is a necessary sequel to it. Large quantities of fluids are discharged through the ileostomy immediately upon its accomplishment, and when one realizes that the right colon where much of the absorption of water takes place normally has been side-tracked, the fluid imbalance which results in dehydration and weight loss, although a serious problem until a physiologic normal has been restored, is not surprising. As time progresses and the ileostomy assumes some of the functions of the large bowel, hypertrophy takes place in its musculature, dilatation accompanies this change, and the stools become semisolid or even formed.

Having once decided to do an ileostomy for adenomatosis or pseudopolyposis it is desirable to construct a single barreled stoma by dividing the ileum close to the ileocecal valve, turning in the cecal end and bringing out the proximal end through a split muscle incision. Formerly, I felt it wise to leave a clamp on this obstructing the end of the bowel for from 36 to 48 hours, but in the recent cases I have been impressed with the advantage of putting a tube into the ileostomy immediately and draining the small bowel from the start. By the use of a mushroom catheter which is held in place by two purse string sutures, leakage is prevented and drainage is advantageously established. It is desirable, after having turned in the cecal end and dropped it back, to shut off the space between the mesentery of the terminal ileum and the lateral parietal peritoneum, thus preventing herniation of loops of small bowel through this aperture, with the development of obstruction.

General abdominal exploration should not be done because in the case of multiple adenomatosis it gives one little information and in the case of chronic ulcerative colitis it is contra-indicated because of the fear of rupturing a concealed perforation, or otherwise damaging the fragile colon to cause leakage and peritonitis.

After the lapse of several months, during which time the patient adjusts his life to the ileostomy and returns somewhat to normal so far as his general condition is concerned, the second stage is performed. Through a long left rectus incision, the colon is removed from right to left. Beginning to mobilize the right colon one cuts the outer leaf of the peritoneum in the blood-

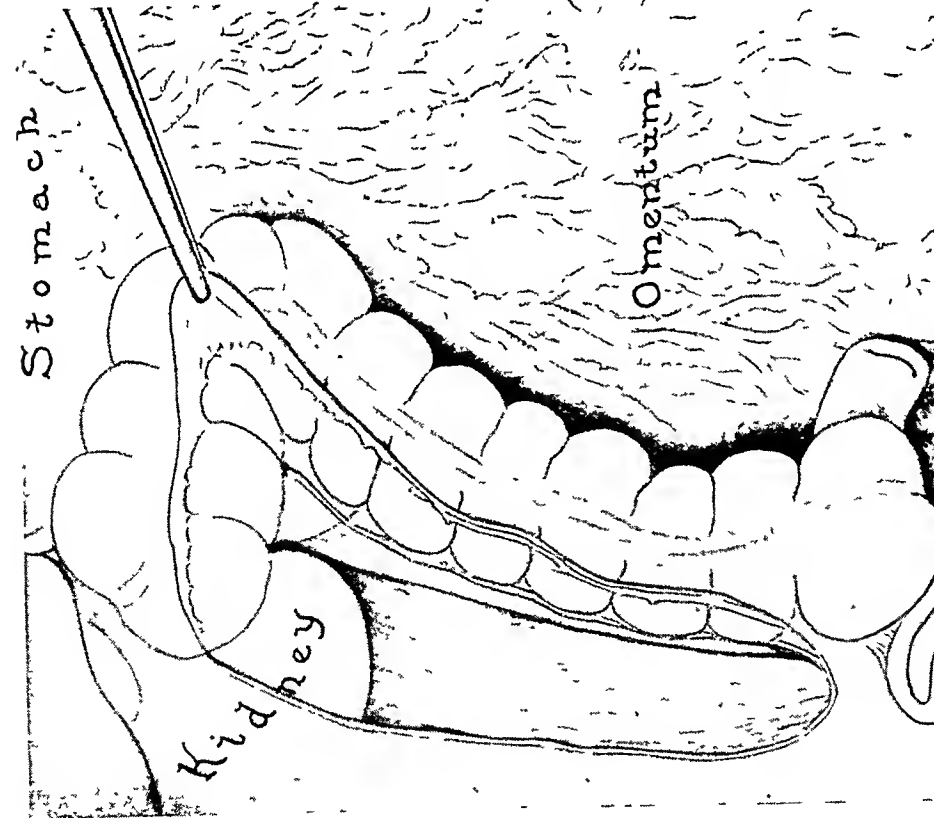


FIG. 5.—The beginning of the mobilization of the colon is shown by dividing the outer leaf of the peritoneum, rotating the colon medially. The blood vessels are ligated close to the colonic wall and peritonealization of this segment up to the hepatic flexure is completed before proceeding further with the mobilization. The omentum is saved usually and in mobilizing the transverse colon it is separated from the large bowel and left attached to the stomach.

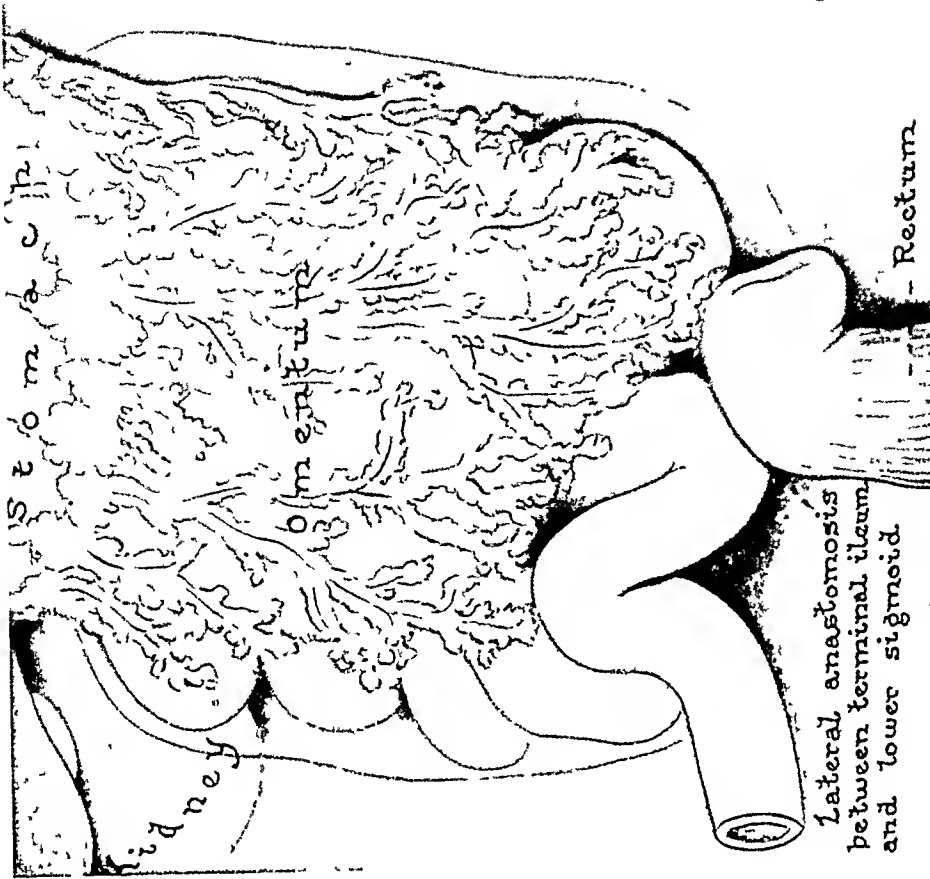


FIG. 6.—Completed operation reestablishing the continuity of the gastrointestinal tract by a lateral anastomosis between the terminal ileum and the lower segment of bowel. The omentum has been saved and covers over the small bowel. The line of peritonealization is shown. The ileostomy is left as a safety valve for a few days following the anastomosis.

less area, rotates the bowel mesially and ligates the blood vessels as they appear, rather close to the bowel wall (Fig. 5). It is not necessary to do a wide dissection like one does in performing a hemicolectomy for malignancy, but by getting rid of the bowel and disturbing the pericolic tissues as little as possible, the success of the operation is enhanced.

It is helpful to accomplish the peritonealization of raw surfaces as the different segments of the bowel are mobilized. The first mobilization goes up to the hepatic flexure where the retroperitoneal duodenum is identified to safeguard it against injury. When the blood supply to this area has been ligated and divided, the raw surfaces are easily covered over by a running suture, bringing the parietal and visceral layers of the peritoneum together. From the hepatic flexure to the splenic flexure is an easy bit of bowel to mobilize if one leaves the omentum. Let me stress this as an important step! There is no difficulty in separating the omentum from the colon and it is very advantageous to have subsequently as a protection against infection and occasionally as a covering for denuded areas.

The splenic flexure is somewhat hard to mobilize as it lies high and is often adherent, but by cutting the splenocolic ligament and the lateral parietal peritoneum down along the margin of the descending colon, one may rotate it mesially and get at the blood supply accurately. Again, the peritonealization of this segment is accomplished by a running suture adjoining the visceral and parietal layers of the peritoneum, and the dissection is carried on to the lower third of the sigmoid. Here the bowel is cut across and the lower end invaginated, the remaining raw surfaces covered, and the abdomen closed without drainage.

The turning in of the lower end of the bowel is a procedure often fraught with considerable difficulty and danger in either the diffuse adenomatosis cases or in the chronic ulcerative colitis variety. In the former the polypi may be so dense and thick that a crushing clamp will cut through the attenuated and thinned-out wall of the bowel if it is applied vigorously. Certainly, in all chronic ulcerative colitis cases a heavy Payr clamp will cut through if applied at all. Experience in the first colectomy which I did for chronic ulcerative colitis was embarrassing, but enlightening, and subsequently it has been found more desirable to clamp the bowel between two soft gastro-enterostomy clamps covered with rubber, divide it with a cautery, and then suture the lower end over and over, closing it as snugly as possible and turning it in as well as might be. This end of the bowel is then wrapped in a piece of iodoform gauze and the whole surrounded with rubber tissue which is brought out through the abdominal wound.

In the adenomatosis cases it is difficult to turn in the end of the bowel when the polypi are diffuse, but it is not impossible. However, one may find multiple fat tags to suture over the stump, and in a woman, may draw down the uterus and broad ligaments to supply peritoneal covering. Where there is any question of secure closure, it is well to drain as in the case of chronic ulcerative colitis. In the case in this series which succumbed, drainage in

this manner was not established and the resulting pelvic abscess was the indirect cause of death.

The third stage of the operation is advantageously delayed a number of months. If one may successfully fulgurate the rectum and destroy all the polypi, it is not unreasonable to spend a year with the ileostomy before attempting an anastomosis. Perhaps in some cases six months will be ample time, but that likely is the minimum. It is surprising how quickly and readily the polypi, even in the most diffuse cases, will disappear when the fecal current is by-passed and when fulguration is vigorously applied. Should one, however, decide to sacrifice the rectum, as was done in most of these cases, the general condition of the patient after the second stage and the continued employment of rehabilitory measures will decide the optimum time.

At the third stage a combined perineo-abdominal resection is performed after the technic which was described in an article in the November, 1931,

issue of Surgery, Gynecology, and Obstetrics. On the other hand, if the rectum has been cleared of polypi and appears relatively normal, an anastomosis between the rectal stump and the terminal ileum may be undertaken. A lateral type of anastomosis between these two segments of bowel perhaps is the most satisfactory and the easiest to accomplish (Fig. 6). It is an advantage to have a safety valve in the form of the ileostomy left for a short while—

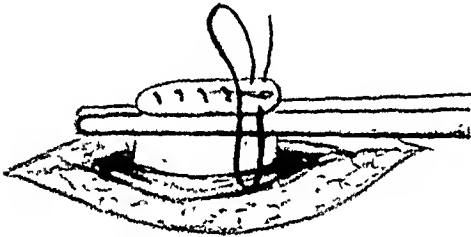


FIG. 7.—Extraperitoneal closure of the ileostomy undertaken a week to ten days following the anastomosis. It is easily accomplished under local anesthesia.

ten days to two weeks—following the anastomosis and this subsequently at another stage, may be easily closed under local anesthesia (Fig. 7).

In the one case in which this graded maneuver was successfully done, preserving the sphincteric mechanism, the outcome to date has been entirely satisfactory and there has been no reappearance of polypi. However, unquestionably one should make frequent proctoscopic examinations of these patients and be constantly on the alert for a return of any polypi.

CONCLUSIONS

(1) An additional report of a series of five cases of colectomy for diffuse adenomatosis and complicated chronic ulcerative colitis is offered. Six cases were previously reported in which the entire colon and rectum was removed by multiple procedures, making a total series of 11. In four cases in this report, the colon was removed down to the rectosigmoid juncture; in the other total colectomy was done. In two cases of the chronic ulcerative colitis variety it is probable that the rectum will have to be removed subsequently, although the patients show marked improvement.

(2) In one case the reestablishment of the continuity of the gastro-

intestinal tract was carried out at the third stage following destruction of the rectal polypi by fulguration.

(3) There was one operative death in this series following the second stage colectomy and in this case likewise, fulguration had been carried out on the rectal polypi and the plan was to transplant it subsequently at a third maneuver, into the terminal ileum. The remarkable disappearance of diffuse rectal polypi following vigorous fulguration is surprising and encourages the belief that this plan which has hitherto been considered an alternative one and available only where the rectal polypi were few in number, may be available to a great many more of these cases.

(4) Technical steps of importance are the preservation of the omentum in the chronic ulcerative colitis group and in the case of adenomatosis where there is no suspicion of malignancy. A second technical point of advantage is the method of handling the rectal stump which turns in with difficulty in many of the polyposis cases and not at all in the chronic ulcerative colitis variety. The stump must be closed over as accurately as possible, covered with whatever tissues there are and if there is any question of leakage, wrapped in iodoform gauze and a rubber tissue to establish a drainage track in the event that the suture line fails to hold.

Of these 11 cases, one died 18 months following the complete operation from recurrence of carcinoma which had developed on the polypi and which was diagnosed at exploration. A second case died two years later following a hysterectomy performed elsewhere. One case died in the hospital following the second stage operation, and the remaining eight cases of the series are alive and well and have all returned to their various occupations.

PEPTIC ULCER AND DISEASES OF THE BILIARY TRACT IN THE SOUTHERN NEGRO

THE INFLUENCE OF DIET

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DURING the ten-year period, 1925-1934, among 60,000 patients (including 15,000 obstetric) admitted to the colored division of the Grady (municipal) Hospital, Atlanta, 119 cases were diagnosed peptic ulcer, and 64 cases were diagnosed as biliary tract disease. During the same period, among 75,000 patients (14,000 obstetric) who entered the white division of the hospital, there were 295 cases of peptic ulcer and 755 cases of biliary tract disease. In other words, in a Southern city of 300,000 population, one-third of whom are Negroes, the incidence of peptic ulcer among white patients admitted to the city hospital was approximately twice as great as among colored patients, while the incidence of diseases of the biliary tract among whites was ten times as great as among Negroes. The percentage of perforated ulcers in the two races was the same, 31 per cent. It has been brought out in a previous paper¹ that in this institution appendicitis is six times more common in white patients than in colored patients.

The comparative rarity of peptic ulcer in the colored race has been noted by other writers, Frank² in Kentucky, and Sturtevant and Shapiro³ in New York. From my impression based on many years' association with the Grady Hospital, I am sure that peptic ulcer is becoming more common among our colored population. Until the above figures were compiled I had no idea that Negroes are subject to the disease as much as half as often as white people. Twenty-five years ago the existence of a gastric or duodenal ulcer in a Negro created a sensation on the wards, while cholecystitis and gallstones were almost unheard of. The ratio of 10 to 1 in gallbladder disease for white as compared to colored patients is more in line with our ideas of the past, although undoubtedly this malady also is being seen more frequently.

What is the reason for the relative scarcity of surgical diseases of the alimentary tract in the colored race, and why are these diseases apparently becoming more general, at least in the South? Undefined racial influences might account to a degree for the smaller number of these cases among Negroes, but the question of diet seems to be a more important element. I became impressed by this fact from the paper of McCarrison on "Faulty Foods in Relation to Gastro-Intestinal Disorder."⁴

In this article McCarrison tells of his surgical experience "in a remote part of the Himalayas where there are located several isolated races far removed from the refinements of civilization . . . races of magnificent physique, pre-

serving until late in life the characters of youth . . . unusually fertile and long lived, and endowed with nervous systems of notable stability."

During nine years' practice among these people McCarrison did not see a single case of gastric or duodenal ulcer, appendicitis, mucous colitis or cancer, although he performed an average of 400 major surgical operations annually. It is not his opinion that such disorders are entirely unknown, but he is positive that they are remarkably uncommon. Diseases of the biliary tract are not mentioned, but most likely come under the same category, although different factors may affect their incidence.

McCarrison believes that the character of food is largely responsible for the absence of such diseases among these tribes, who live on the "unsophisticated foods of nature," such as milk, eggs, grains, fruits, vegetables and very little meat and sugar. Moreover, such foods are produced close to the communities where they are consumed so that it is not necessary to prepare them for preservation and transportation.

How do these articles of diet compare with the foods of civilized man, among whom diseases of the digestive tract are so universal and serious? On account of the crowded conditions of modern life, making the preserving and shipping of food obligatory, our food is polished, sterilized, pickled, canned, frozen, thawed and otherwise treated until its health sustaining ingredients are materially impaired or destroyed. Is it any wonder, then, that we suffer from all kinds of digestive disturbances of which McCarrison's East Indians know nothing?

To disprove what might be claimed, that the paucity of alimentary diseases among these people is due to racial peculiarities, McCarrison had opportunity to observe the health of a large group of one of these races which was compelled to move to another district where their former foods could not be obtained. Immediately many of them developed sicknesses which did not affect them while partaking of their accustomed nutriment. He further proved his contention as to the results of faulty foods in experiments upon wild monkeys made to subsist upon unnatural, artificially prepared diet.

The food of the Southern Negro compares in a measure with that of the natives of the Himalayas. As choice diet Negroes first select fresh green vegetables (turnip greens, collards and cabbage) and a mixed juice made from them, "pot likker." They enjoy other vegetables like "cow-peas," string beans and potatoes, and eat various cereals. Their favorite bread is corn bread, better made from water-ground meal. Fresh fish they love dearly, but similarly to the Himalayans, they do not consume a great amount of meat, except the cheaper kinds of bacon; and are not especially fond of sugar and sweets. Hog meat, particularly "Andy's" pork chops, is their preference, but not generally included in the menu on account of the expense. The same reason applies to chicken. Coffee and tea do not appeal to their appetites, but they relish lemonade, even for breakfast. Milk and eggs are costly and in contrast to the Himalayan custom, such valuable foods do not appear regularly on the table of the Southern Negro.

No matter what rich and delicate viands the colored person as cook or butler may place upon the white folks' table, when he can get it the Negro chooses for himself food as outlined above. It is interesting to observe that, opposed to the rules of dietetic hygiene, he demands his victuals fried and sopped in grease, from which he rarely suffers the pangs of indigestion.

Close inquiry in the homes of the victims of peptic ulcer revealed the fact that the majority of such victims, not all, had strayed away from their natural diet and had indulged in the fare of modern civilization. Some of them worked in homes where they could not obtain the food which agrees with them so well, or they remained away for long periods employed in a store or shop and ate at a lunch counter where the can opener is so freely used. Negroes do not eat canned foods and it is most unusual to find such an article in their homes. Careful investigation was made of this point. As the colored population consumes more unnatural and over treated nutriment, and less of the richly vitamized "pot likker" type, alimentary ailments grow in number among them.

Granted that an important factor in the etiology of the common diseases of the digestive system is faulty food, is it possible to correct it? Could, or would other people be willing to derive their nutrition by such means as described above? I think not. Certainly but little change could be accomplished in a generation. However, thorough study might suggest methods of improving our diet along some of the lines indicated. Social workers, hygienists, public health agents and others could render assistance. McCarrison declares that the East Indian babies are entirely breast fed, or they die. Negroes also seldom resort to any other variety of infant feeding. Here is the place and time for us to begin building resistance against these diseases. Scientifically devised foods often are life-saving, but are not the pediatricians, in spite of their valuable contributions to medicine, too prone to aid and abet modern mothers in substituting artificial nourishment for nature's "unsophisticated" pabulum?

Peptic Ulcer Statistics.—Of the 119 cases of peptic ulcer, 91 were in males and 28 in females, the youngest patient being 15 and the oldest 70. Of gastric ulcer there were 46 cases, 18 being perforated; duodenal ulcer, 73, 19 perforated. Hemorrhage occurred in three gastric cases, and in nine duodenal cases.

Twenty-one patients with gastric ulcer were subjected to operation, with six deaths, four of the ulcers having ruptured from six hours to one day previously. Another death resulted from heart complication, and another from excision of the ulcer, all other ulcers being sutured only.

Twenty-three patients with duodenal ulcer were operated upon, with one death, following rupture 30 hours previously. Incision for appendectomy was made in one case which turned out to be duodenal ulcer.

There were 14 deaths among the 75 patients who did not have operation, giving a total mortality of 17 per cent in the 119 patients admitted. Among the 21 patients who were deceased, nine had ruptured ulcers, four not being subjected to operation.

From the high mortality given, it is apparent that many of the patients were received in poor condition, particularly on account of hemorrhage and perforation. Gastro-enterostomy was performed in two gastric cases, with one death from heart complication; excision of ulcer was done in two gastric cases, with one death. Gastro-enterostomy was the operation in nine duodenal cases, with no deaths. Perforation took place in one patient six days before admission, and in another patient two weeks before admission.

Roentgenologic examination gave positive evidence of ulcer in 19 of the 46 gastric cases, and in 52 of the 73 duodenal cases. Most of the patients with perforation had no such examination. Four who were examined showed free gas in the peritoneal cavity. The ulcer in one patient admitted in 1935 perforated while he was standing behind the fluoroscope, and gas could be seen escaping from the duodenum. He was operated upon, but died later from embolism.

The majority of patients who received medical treatment, and these constituted more than half the number of patients admitted, were dismissed from the hospital as improved. There is record of only three such patients returning to the hospital later for operation. During the ten-year period 43 other patients entered the hospital supposed to have peptic ulcer, but complete examination failed to confirm the diagnosis.

Statistics in Diseases of the Biliary Tract.—Of the 64 cases of biliary tract disease, 12 were in males and 52 were in females, the youngest patient being 14 and the oldest 60. There were 12 cases of acute cholecystitis, in three of which empyema was present; and 52 cases of chronic cholecystitis. Fifteen patients had jaundice, which is not easy to detect in a colored person.

Stones were found in the gallbladder in 19 cases, and in the common duct in three. Roentgenography showed gallbladder calculi in all but three cases.

Thirty-seven patients were operated upon, 26 having cholecystectomy and 11 cholecystostomy. The gallbladder was drained in three instances, and removed at subsequent operations.

Eight patients died, giving a mortality rate of 14 per cent. Four of the patients were operated upon, two of whom had common duct stones, anastomosis between the common duct and duodenum being attempted in one instance. Another patient died following cholecystectomy, and another following cholecystostomy, complicated by blood stream infection. Of the four fatal cases in which no operation was performed, one had acute cholecystitis, one empyema of the gallbladder, one nephritis, and one suspected carcinoma of the gallbladder.

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LIVER RESECTION

CASE REPORT AND ADVANTAGES OF RADIOCUTTING

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RESECTION of the liver has not been of frequent occurrence. Few surgeons have operated upon more than one such case, but 21 members of this Association have had a total experience of 24 cases. Fifteen of these have been reported in the literature, but eight including this communication have not been previously reported.*

The cases collected by Thoele,¹ in 1913, doubtless include most cases reported up to that date. It is evident that this procedure is important enough so that it should be kept in mind by surgeons.

The safety to life and permanent results might have been more satisfactory had the operators been familiar with methods previously used. The diagnosis of liver tumor before operation has seldom been made, hence preparation for dealing with it has been quite inadequate. The difficulties of liver resection depend largely on the location, attachment, character, and size of the growth. Pedunculated growths are almost always easily managed and fortunately are of somewhat common occurrence. Growths at or near the anterior edge of the liver, because of their accessibility, are also usually relatively easily removed. Growths on the under surface of the liver are usually less easily removed, also those located high under the diaphragm or far toward the back. Extensive growths frequently, although not always, offer greater difficulty. Any growth when embedded deeply in the substance of the liver is more apt to prove troublesome.

CONTROL OF HEMORRHAGE

This is by far the most important problem in liver resection. Oozing is apt to be profuse and persistent with ordinary cutting methods. The liver tissue is friable and frequently does not hold ligatures or sutures particularly well. Large vessels embedded in the liver substance are sometimes difficult to pick up with artery forceps or tie readily. The many methods of controlling hemorrhage which have been used indicate that there is no single infallible method.

Controlling Hemorrhage.—Temporary control of profuse oozing has been obtained by pressure of gauze wrung out of hot saline solution and applied to the cut surface. Adrenalin has sometimes been added to the solution. The liver has been held compressed by assistants or in certain instances

* This number has been greatly increased by personal communications to me since this paper was presented before the American Surgical Association at Boston, June 8, 1935, and will be included in a paper now in preparation.

temporary clamps have been applied. Lillienthal controlled hemorrhage by traction on the growth during removal. The vessels supplying the liver have been temporarily compressed by rubber covered clamps (John R. McDill²). This same method was reported (independently?) by Borzoky and Baron³ a year later. Superheated air was used by Hollander.⁴

Gauze packing by Mikulicz, or other methods, has been left in place for several days; sometimes its removal has been followed by secondary hemorrhage. Elastic ligature, sometimes held by transfixion pins; also extraperitoneal treatment of the stump, was used by a number of earlier operators. These methods have not been employed recently because of slower healing and the risk of infection. Suture through liver substance over some supporting structure has been used; metal and celluloid plates, fresh or decalci-

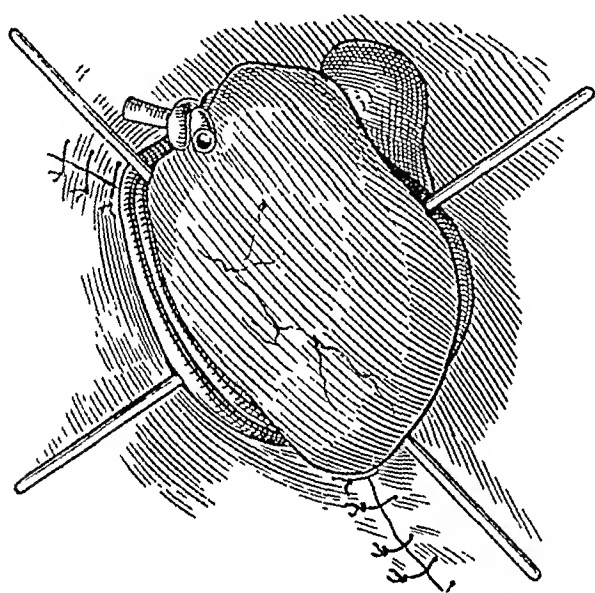


FIG. 1.

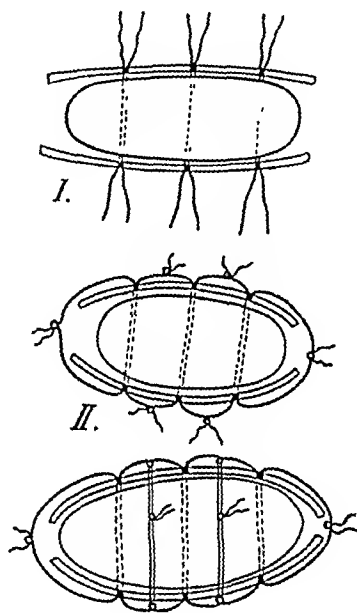


FIG. 2.

FIG. 1.—Shows transfixion holding elastic ligature (now seldom used).
FIG. 2.—Suture chain ligature. Has been used with or without support of metal, celluloid, bone plates, or fascial strip to prevent cutting of liver substance.

fied bone and fascial strips have been employed for this purpose. The method of Leonard Freeman, to be described in the discussion, seems the simplest and most practical of these. The actual cautery has been used in cutting by several with excellent results; it does control oozing and many of the small and medium sized vessels and destroys malignancy. Whether it accomplishes these ends as satisfactorily as electrosurgery will be discussed later. Various forms of mass suture without other support, as mentioned above, have been used since the earliest liver resections and are still the main dependence for control of hemorrhage by a large number of surgeons. The mattress suture is far more commonly used; cobbler stitch, interlocking suture, chain suture, Lembert suture, and continuous whipping over of the cut edges are mentioned.

Electrosurgery seems well established as the standard procedure in many lines of surgery. The only records of its use for liver resection are three besides my own. Ward⁵ reports excision in 1930 of a liver sinus persisting

one and one-half years following drainage of a large echinococcus cyst. The excision extended down close to the vena cava, and the hemorrhage was so well controlled that it was possible to close the abdomen without drainage; a good recovery followed. Howard Gray⁶ reports removal of a squamous cell epithelioma Grade 4, involving the region of the gallbladder, 12 cm. in diameter, by diathermy, controlling larger bleeding points by coagulation, ligation and mattress suture. He emphasizes the value of diathermy in resecting malignant lesions which when dissected by knife would be exceptionally difficult. Coller, of the University of Michigan, began a resection of an adenocarcinoma of the left lobe by coagulating current but discarded it in favor of the scalpel. A number of surgeons presented evidence of the value of electrosurgery at a recent Symposium of the American College of Surgeons. The brain surgeons, following the leadership of Harvey Cushing, all use it. De Quervain of Bern, Switzerland, uses it in his goiter surgery. Its

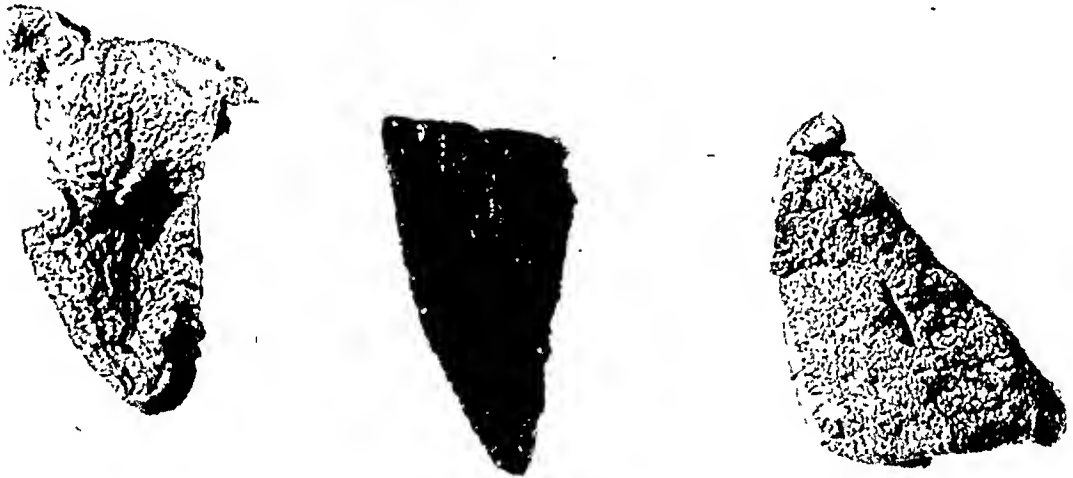


FIG. 3.—Photograph of pieces of liver cut by canter, middle; scalpel, left; radiocutting, right.

value in dealing with other highly vascular parenchymatous organs has been shown by both experimental and clinical experience and it should be more widely used especially in such work.

An experimental study on dogs of electrocutting and coagulation in the surgery of highly vascular organs was made by Ward and Pearse⁷ at the Hunterian Laboratory, Johns Hopkins Medical School. They found it possible to arrest oozing while cutting and control larger vessels by clamp and coagulation without the use of any other measure. Scott⁸ reported five cases of removal of renal calculi through an electrosurgical incision, and also resection of the kidney. Pugh⁹ has also done nephrotomies and resection of the kidney electrosurgically. During the past six years I have personally used electrosurgery in 780 goiter operations, many of them extremely vascular exophthalmic or malignant growths, which would have oozed profusely with ordinary sharp cutting. I believe it safer to tie all moderate sized as well as larger vessels. Its advantages in malignant goiter were brought to the attention of this Association in 1931,¹⁰ by the author. The conditions in kidney and cer-

tain goiter surgery as concerns oozing and the friable character of the tissues through which sutures or ligatures, readily cut, are quite similar to those met in liver surgery. Radiocutting is far less destructive than actual cautery; it cuts much faster and I consider it equally efficacious in arresting oozing. It has given me better results during five years' use than any of the three spark-gap high frequency outfits which I have tried.

REGENERATION AND BLOOD SUPPLY

A favorable factor in liver resection is that regeneration occurs promptly and quite completely. Ponfick,¹¹ over 40 years ago, reported experimental studies showing this. These studies were confirmed by Von Meister,¹² who removed up to four-fifths of the organ in rabbits, rats and dogs. Recently Fishback¹³ removed one-fifth to three-quarters of the liver and found four-fifths regeneration in six to eight weeks. Clinically, Wendel¹⁴ has shown that these experimental results can be relied upon. July 18, 1910, he removed most of the right lobe from a woman of 44 for primary adenocarcinoma. Two years later it was necessary to excise a considerable part of the colon and enlarged lymphatic nodes; microscopically the growth was similar in structure to the liver tumor previously removed; the liver itself showed no recurrence. The patient died August 25, 1919, and postmortem examination showed extensive local and metastatic recurrence. Wendel suggested to his associate, Martens¹⁵ that study of the blood supply of the liver would be of value to those who might be called upon to do a resection. His injection and corrosion specimens show that the right hepatic artery anastomoses with branches of the left lobe (Fig. 7), so that either lobe would probably receive adequate blood supply if the artery of the opposite side were divided. It also shows that the left lobe and lobus quadratus are supplied by the left branch of the hepatic artery: that the right lobe is supplied and the lobus caudatus mainly supplied by the right hepatic artery but that the lobus caudatus also receives a small branch from the left hepatic artery. This distribution of blood supply safeguards remaining liver substance in case radical resection of either lobe is necessary, with sacrifice of blood supply of that side.

TUMORS REQUIRING LIVER RESECTION

There have been reported a number of resections for growths, proved by pathologic examination to be gummata. Among members of this Association, Abbe¹⁶ and Thompson¹⁷ have both reported such cases. Ransohof¹⁸ reported excision of a tuberculoma. Several growths reported to be adenoma have later proved to be malignant, probably adenocarcinoma. In some instances these growths have been reoperated upon; in others postmortem examination or clinical symptoms have left little doubt as to their malignancy. Among malignant growths sarcoma has been relatively infrequently reported. Elliott¹⁹ reported such a case. Ewing²⁰ indicates that there is great difficulty in determining the exact character of the growth in these cases and questions the

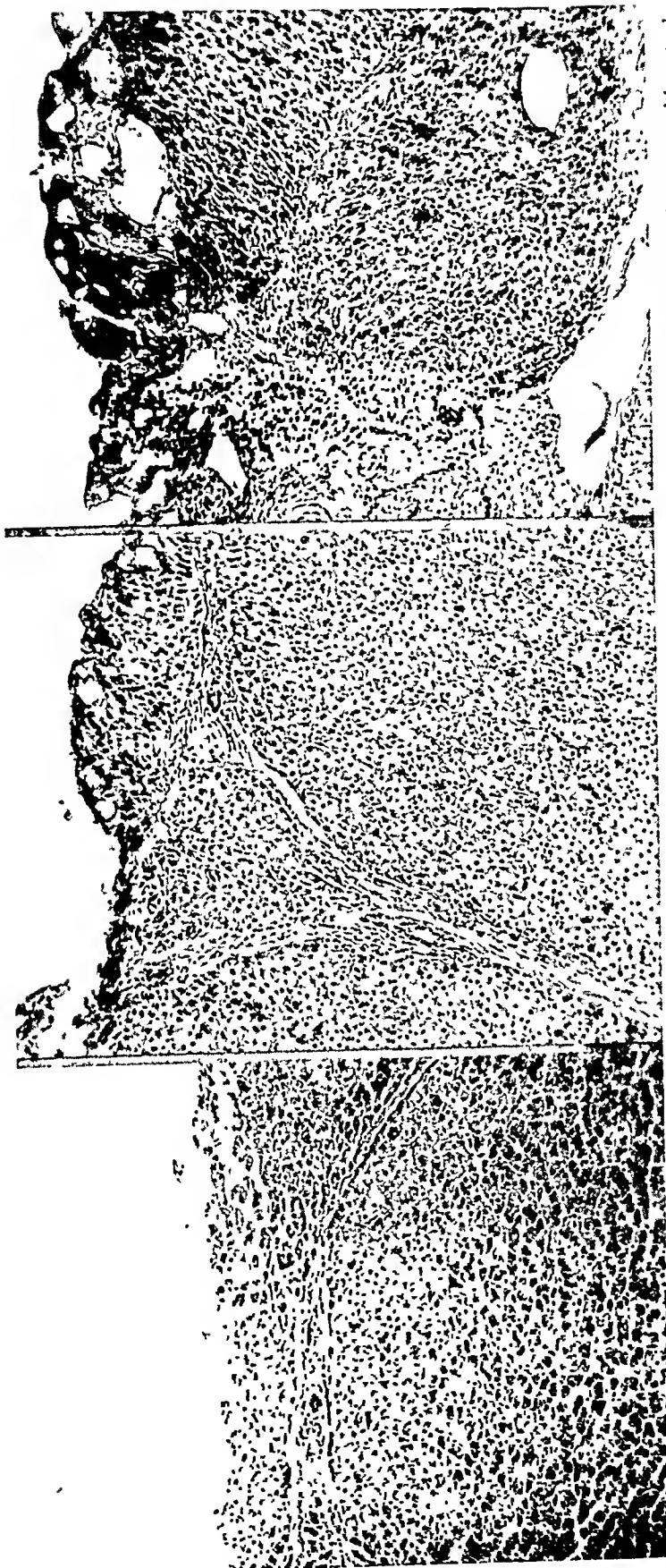


FIG. 4.—Photomicrograph showing liver surface cut with scalpel.

FIG. 5.—Photomicrograph showing liver surface with radio cutting (electro surgery).

FIG. 6.—Photomicrograph of liver cut with actual cautery, showing extensive destruction.

occurrence of sarcoma. The same is true of hypernephroma affecting the liver. Echinococcus cysts have been treated by resection of the liver by a number of surgeons, frequently because of mistaken diagnosis: simpler methods are now generally used. The two most important growths requiring liver resection are hemangioma and primary cancer of the liver. Because of their greater frequency and the possibility of curability I shall discuss these growths in more detail.

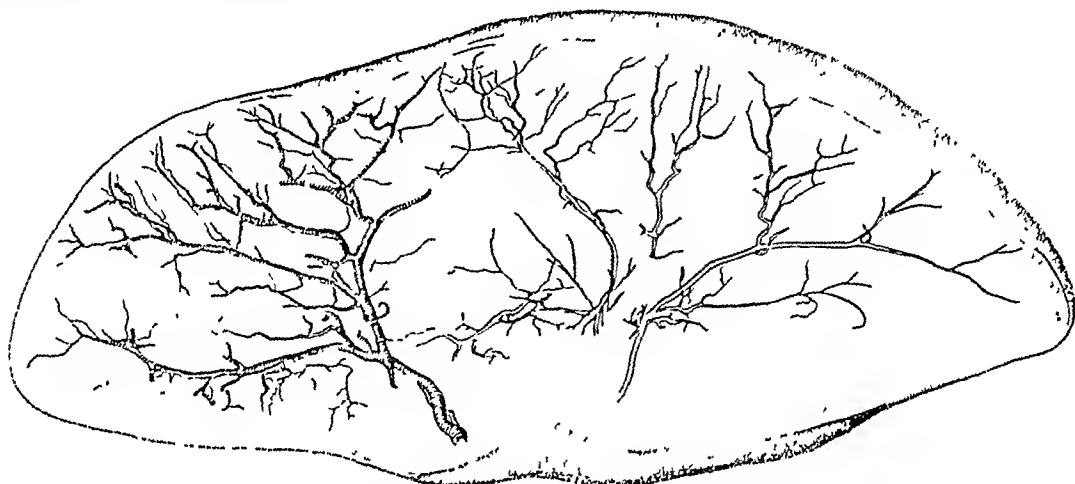


FIG. 7.—Drawing made from half tone of Martens article in Arch. f. klin. Chir. see text, for complete reference. Shows filling of blood vessels of left lobe of liver when right branch of hepatic artery is injected. The free anastomosis would be favorable to extensive resection in case either branch of the hepatic artery was cut off.

Cavernous Hemangioma offers special difficulties with regard to hemorrhage. The tumor is so thinned walled, in some instances, that rupture occurs and hemorrhage causes the symptoms which first call attention to some serious intra-abdominal condition. This occurred in the case which I report. Turner²¹ reported the case of a patient admitted to Guy's Hospital in collapse; a diagnosis of ruptured ectopic pregnancy was made: the abdomen

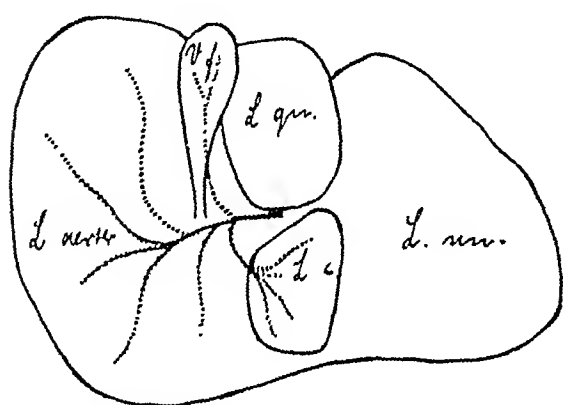


FIG. 8.—Distribution of right branch of hepatic artery to right lobe and most of lobus quadratus.

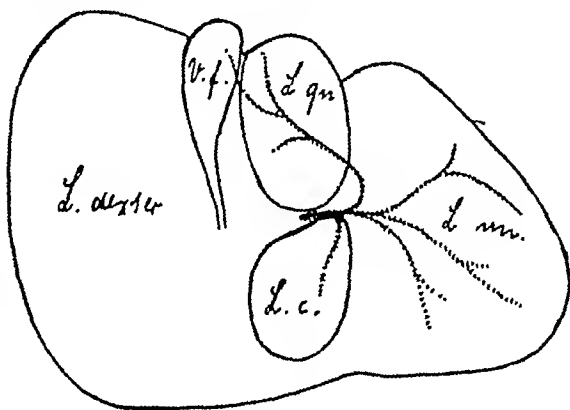


FIG. 9.—Distribution of left branch of hepatic artery to left lobe, lobus quadratus and twig to candate lobe.

was found to be full of blood; the pelvis was normal; hemorrhage from a liver hemangioma could not be controlled by suture or packing; the tumor was removed by cautery and the patient was given an infusion but died after one hour. There seems a possibility that this patient might have been saved by transfusion of her own blood taken from her abdomen: this method was first suggested by Halsted: I have used it successfully in a case of severe

bleeding from ectopic pregnancy. Severe hemorrhage from a needle prick of a huge angioma of the right lobe is reported by Mantle²² and quoted by Chas. H. Peck.²³ The hemorrhage was uncontrollable by suture or packing and the patient died after two hours. Fatal hemorrhage was also reported by Borst and Chiari²⁴ and by a number of others. The fairly frequent pedunculated hemangiomas are much less difficult and dangerous. Peck²³ reported a pedunculated hemangioma involving the entire left lobe which was removed after clamping the pedicle and closing the stump with continuous catgut suture; the tumor weighed 3 pounds 14 ounces (1,759 Gm.), the largest tumor removed in this country up to the time of this report. Clar²⁵ gives details of a successful operation by Schloffer, with a report of 30 others from the literature, an operative mortality of slightly over one-third of 1 per cent. This perhaps gives a fair estimate of present day risk.

CASE REPORT: A woman 65 years of age consulted Dr. H. E. Merriam because of abdominal pain. Her condition did not seem serious but there was some abdominal tenderness localized mainly in the right lower quadrant. There was a history of dull abdominal aching for 30 years. The family and past history were unimportant. General physical examination satisfactory. The following morning the pain became more severe, was localized at McBurney's point and the patient was sent to the hospital and prepared for operation. The abdomen was opened and much free blood was found, some old and clotted. No source of bleeding was discovered in the lower abdomen but an actively oozing tumor was found attached to the left lobe of the liver. This was resected wide of the growth with medium cutting radiocurrent, which controlled all smaller vessels. Larger vessels were controlled and approximation of the defect effected by mattress sutures of plain catgut. Xeroform gauze drain was left to line of suture. Clysis was given. Recovery was uneventful. The patient is living and well 16 months after operation. Pathologic Diagnosis: Hemangioma of the liver.

MALIGNANT TUMORS OF THE LIVER

Many writers are pessimistic towards resection of these growths. This has probably led many surgeons to abandon attempt at their removal, although the experience of Keen,²⁶ McArthur,²⁷ and Yeomans²⁸ among the Americans and the successes of a number of foreign surgeons have shown the possibility of cures up to seven years' duration. A reliable pathologic diagnosis is indispensable in such cases. In Keen's²⁶ case the pathologic diagnosis, cylindrical cell cancer by Coplin and Tinker, was confirmed by Wm. H. Welch and T. M. Prudden: in McArthur's²⁷ case pathologic diagnosis, adenocarcinoma by Hektoen and Zeit, was confirmed by Fenger: in Yeomans'²⁸ case the pathologic diagnosis, adenocarcinoma by Jefferies of the Philadelphia Polyclinic, was confirmed by Ewing.²⁰ McArthur's case involved especial difficulties, for the liver was involved by extension from stomach cancer, so that resection of the stomach as well as the liver was required: the later pathologic diagnosis was true carcinoma. Alessandri²⁹ states that "in carcinomata of the liver, surgery is of scarcely any interest as they are operable only in exceptional instances." He does state farther on that "adenocarcinomata, especially when they develop in accessory lobes . . . are in consequence insolated and sometimes circumscribed and pendunculated

and may be operable," also that "metastases . . . are rarely seen." Ewing²⁰ and McCallum³⁰ also confirm this statement as regard metastases. The improvement in methods and additional resources of recent surgery have much improved the prospects of cure. Case reports have been collected by Keen,²⁶ Thoele,¹ Yeomans,²⁸ and Castle.³¹

It should be noted that unfavorable statistics, in several cases, are based upon operations which were performed under conditions less favorable than the present, 25 to 40 or more years ago. Also that Keen's tabulation, pub-

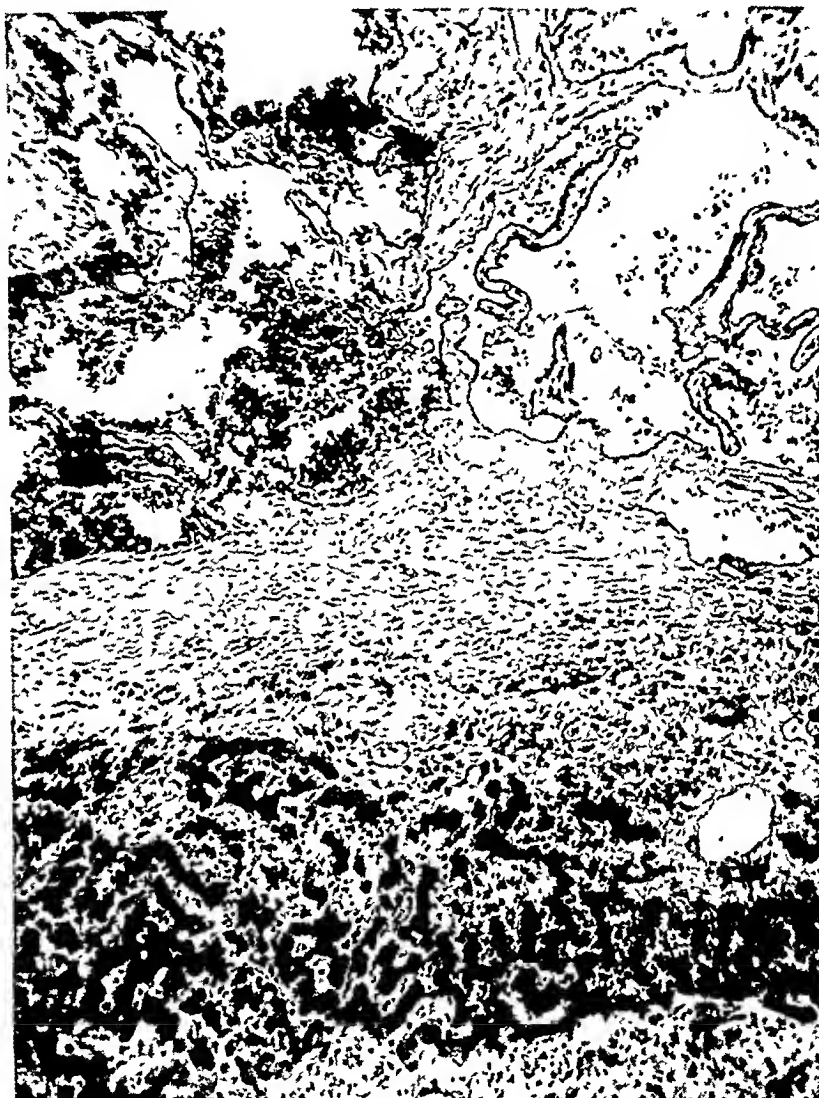


FIG. 10.—Photomicrograph of the hemangioma of liver reported

lished in 1899, includes two patients living three years after operation which were apparently overlooked by Thoele in 1913. All but two of Thoele's collected cases were operated upon 25 or more years ago: but even at that time two of these (6 per cent plus) were apparently living and well three or more years postoperatively, and four (12.5 per cent) lived three and one-half years or more, a gain in life which at least in some cases would warrant operation. Yeomans' tabulation, which includes several cases operated upon 20 years or less ago, shows six (37.5 per cent) of 16 patients alive and well three to seven years after operation. This compares fairly favorably with the re-

sults in thyroid malignancy which also deals with a glandular, very vascular, organ. Most of the improvement in the results in the treatment of thyroid malignancy seems to have come from recognition of the value of irradiation combined with surgery: neither irradiation nor surgery alone gives results comparable with the combination of the two. Is it not possible that such improved results might come with this combination in liver surgery? Earlier exploration, as urged by Keen and Yeomans, is also highly important, for in extremely few cases has liver malignancy been suspected before the abdomen was opened; almost every other possibility has been first considered. A disadvantage unlikely to be avoided is that the experience of the individual surgeon is likely to remain small. Adenocarcinomata, which makes up a large percentage of liver malignancies, often grow slowly and metastasize late if at all, as stated by Ewing and McCallum, and are classed as radio sensitive.

With improved aseptic and antiseptic technic; with methods of anesthesia adapted to the individual case; and with some knowledge of the experience of the many others who have previously operated, results both as to safety and permanent cure should show still further improvement over earlier reported cases.

CONCLUSIONS

(1) The incidence of liver tumors is large enough so that their occurrence should be kept in mind.

(2) Reproduction of liver tissue has been shown experimentally and clinically; the blood supply is favorable and both experimental and clinical evidence indicates that large growths can be excised safely.

(3) Radiocutting combined with other methods suited to the individual case, transfusion of the patient's own blood from within the abdominal cavity in bleeding hemangiomas; and radium combined with surgery in malignancy may help to raise the percentage of cures.

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DISCUSSION.—DR. HOWARD LILLIENTHAL (New York).—In discussing Dr. Tinker's most interesting paper let me give my experience in two cases that I have had. The first one, a man of about 50, was operated upon long ago. The tumor depended from the right lobe of the liver. I extirpated it. As I drew the tumor downward during its removal I could see the vessels like the strings of molasses candy when you pull it apart. I caught every one and tied them. I had no trouble, whatever, and my impression is that I sutured the defect afterward. The neoplasm proved to be an hypernephroma. The patient recovered but because of inexperience in those days I did not investigate the case further nor follow the patient later on. It probably was a secondary hypernephroma, I would now make every possible effort to find the primary lesion, since in hypernephroma there may be a single or solitary metastasis.

The other case was one of hemangiosarcoma, a large one in a woman. It also was in the right hepatic lobe. My impression is that I made use of a pin with the elastic ligature during the extirpation. The case was an extremely difficult one. I think that this patient died a year or more after an operative recovery.

I have had several patients with hydatid cysts of the liver. In one of them there were five present; I took out three at one time and two at a subsequent operation. The man got well. Another had a single hydatid cyst. It was found accidentally while operating for gallstones. I did both operations at one time with recovery.

I am very partial to electrosurgery of the right kind. You should have a current that will cut rapidly. The so called radiocurrent I have had no experience with in the liver. I use it for the skin always and get much better primary union than with the scalpel. If you use it for the skin you should make the incision quickly. A slowly made incision will kill the adjacent tissue. I use electrosurgery in all my work except the intrathoracic, and I am afraid to use it there because cases have been reported, but not published, in which the patient has died on account of electric shock to the heart muscle. In most other parts of the body, you will have nothing but good luck if you handle the radioknife correctly.

DR. LEONARD FREEMAN (Denver, Colo.).—Doctor Tinker has described what seems to be an excellent method for resection of the liver, provided one has the proper apparatus at hand. But the necessity for a resection sometimes comes unexpectedly when an electric knife is not available.

In such emergencies it is well to have some other means up one's sleeve. There are a number of more or less good methods which may be used; but one which I suggested before this Society some years ago has advantages in the way of simplicity and effectiveness which make it deserving of attention. It has served me well on several occasions.

The paraphernalia required consists of two mattress needles, or two sections of stiff wire, about a foot or more in length. One of these is laid along the upper surface and one along the lower surface of the section of liver to be removed, well back from the tumor. With a long straight or moderately curved needle, plunged through the liver, two or more loops of catgut are slung, at appropriate distances, around the lower mattress needle and over the upper one.

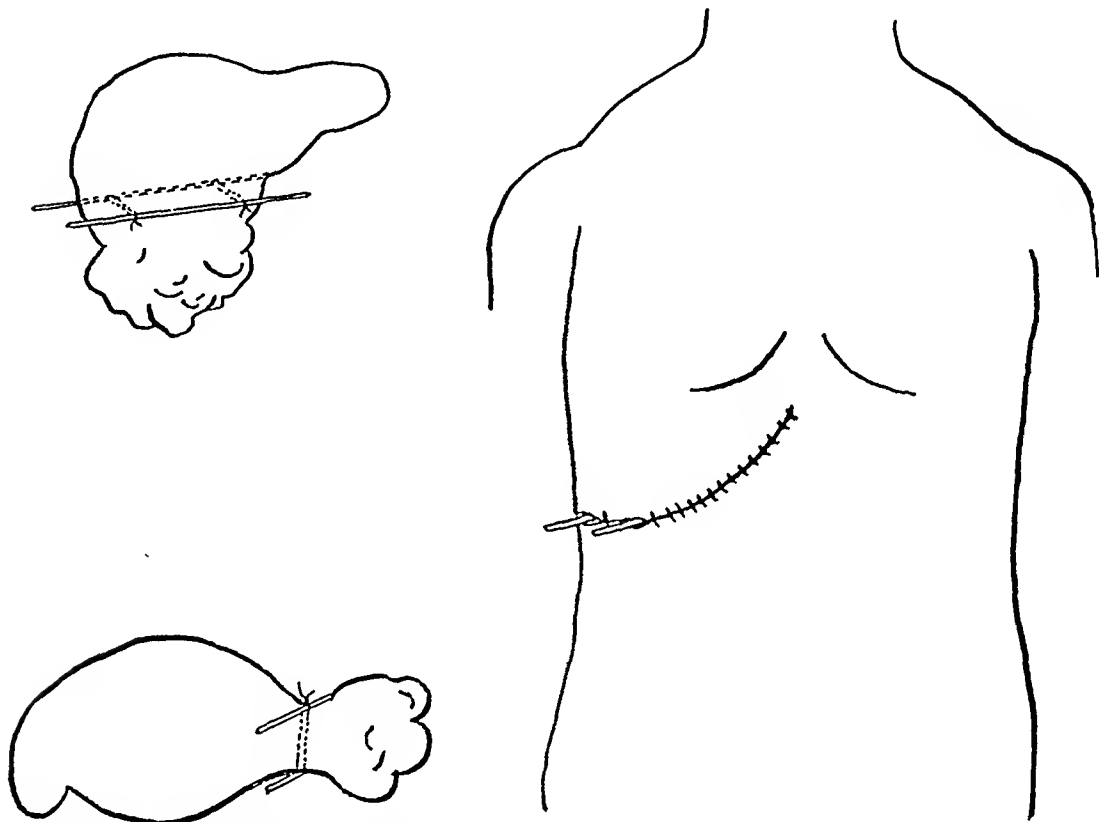


FIG. 11.—Showing mattress needles in place, held by catgut loops passing through liver.

FIG. 12.—Lateral view of liver and tumor and needles in position.

FIG. 13.—Showing needles brought out through incision.

When the loops are tightly tied they compress the liver substance between the wires so that no bleeding can occur and the needles cannot slip. If the incision is oblique the ends of the needles are conducted out of its lateral extremity onto the abdominal wall, or a separate stab wound may be made for this purpose (Figs. 11, 12 and 13). At the end of a number of days the needles are easily pulled out, leaving the catgut loops to be absorbed later on.

DR. FRED B. LUND (Boston, Mass.).—I have nothing, whatever, to contribute to the technic of removing tumors of the liver. I am simply speaking of this case on account of the condition for which it was done. Some 30 years ago I was called upon to operate upon a woman suffering from a tumor of the liver. It was before roentgenography and also before the time of electric knives.

She had an enormous tumor in the upper right quadrant extending way

down below the umbilicus. We thought it was a tumor of the kidney. Her urine was normal. She was about 50 years old. She had no loss of weight, but just presented this great big tumor that was bulky and bothered her greatly.

You are all familiar with congenital cystic kidneys. This patient had a congenital cystic liver. The cysts were not distributed through the liver. It was all one mass. By taking out a big, wedge-shaped piece of the right lobe, I could get rid of it and I did shell it out. There was the usual bleeding and transfusions were just beginning to be done. I used hot water. I had some great long blunt needles and brought the surfaces together, except at one point where I had to pack with gauze. We have all had some experience with packing with gauze in cases of ruptured liver, and it works a good many times. In taking out gallbladders you sometimes get into the liver, expose the raw surface, and that can always be cured by packing.

I do not think the venous blood pressure in the liver is high at all. In bringing in the blood they spread out like a mountain stream flowing into a lake and there is no current to speak of in the lake and the current is slow in the river. I always thought it was a hopeful point.

One chief difficulty is the fact that sutures cut through the soft liver tissue. In cases such as Dr. Freeman has suggested, I think that his method is excellent if it can be applied. I did sew this liver up with mattress sutures and a gauze drain, and while we were arranging for a donor she died from hemorrhage and shock.

DR. EDWIN BEER (New York).—In connection with the use of the radio-knife, it is of interest to know that in 1908 or 1909 the radio expert Lee deForest asked me to try out the cutting current on animals in the Loomis Laboratory in New York. The cutting effect of this current was satisfactory, but its hemostatic effect, especially in organs like the liver, as Dr. Tinker indicated, was imperfect. Large vessels remained open and bled. Since then we have been able to produce a combined cutting current and electro-coagulating current which frequently controls the bleeding. The disadvantage from electrocoagulation of the tissue to control bleeding is in the fact that this coagulated tissue may invite infection. Both currents are high frequency currents with very rapid oscillations.

I have personally had experience with two cases of liver resection, one case an hemangioma of the liver. It was impossible to control the bleeding completely by all sorts of ingenious devices. In another case of sarcoma of the right lobe of the liver, a resection was rapidly made and the bleeding controlled by enfolding stitches of the thinned out liver edge surrounding the sarcoma so that no packing was necessary to control the oozing. The tumor was the size of an orange, easily removed, and the patient died five and one-half years later with multiple metastases in bones, liver, spleen and kidney.

In closing, I believe it should be emphasized that the high frequency cutting and coagulating currents are invaluable in resection of hollow organs, especially the bladder, where I have been using these currents for over 11 years.

DR. JAMES M. MASON (Birmingham, Ala.).—Relative to the question of autotransfusion, this has been extensively and successfully used by gynecologists in ectopic pregnancy. It has been used rather infrequently in other conditions, although in any uncontaminated intra-abdominal hemorrhage I see no reason why the blood would not be just as available for autotransfusion as in ectopic pregnancy. I have used it very successfully in ruptured spleen. I have not used it in ruptured liver.

I see no reason why blood that is uncontaminated by injury to the urinary or intestinal tract might not be used in case of hemorrhage from the liver, unless associated with the malignancy of the liver, where there might possibly be danger of picking up cancer cells.

DR. JOHN J. MORTON (Rochester, N. Y.).—Relative to the use of extravasated blood from the liver as a transfusion, we were warned, in Dean Lewis' clinic, at Baltimore, that blood extravasated from the liver is very dangerous as it carries a toxic choline derivative in it.

DR. EMMETT RIXFORD (San Francisco, Calif.).—Doctor Tinker spoke of the capacity of the liver for regeneration. It is certainly remarkable, as may be shown from the following example: A man came to hospital with enormous masses of varicose veins extending from each groin to the corresponding axilla, evidently the result of obstruction of the vena cava. He gave a history of having had typhoid fever in the Presbyterian Hospital, New York, 14 years previously, followed by swollen legs. From the hospital it was learned that the typhoid had been accompanied and followed by phlebitis of the iliacs and vena cava. Some months later the patient returned to the hospital suffering from abdominal pain. Fatal peritonitis suddenly developed. Autopsy showed that the right lobe of the liver had been entirely replaced by two large cysts, one of which had ruptured, causing the peritonitis. The left lobe of the liver had hypertrophied to be as large as both lobes of the normal liver. It may be of interest to state that the ascending vena cava was represented by a bone which extended from near the level of the renal veins downwards into the iliacs.

DR. MARTIN B. TINKER (Ithaca, N. Y.).—It may interest the American Surgical Association to recite a list of their members who have reported cases of liver resection in the past: Dr. McLean Tiffany, Baltimore, Dr. J. W. Elliott, Boston, Dr. Monks, Boston, Dr. Alexander Hugh Ferguson, Chicago, Dr. Louis McArthur, Chicago, Dr. Oliver, Cincinnati, Dr. Ransohoff, Cincinnati, Dr. Leonard Freeman, Denver, Dr. Robert Abbe, New York, Dr. Willy Meyer, New York, Dr. Charles Peck, New York, Dr. W. W. Keen, Philadelphia, and Dr. Alexander Maclaren, St. Paul.

Of this list, Doctor Keen reported three cases, Doctors Ferguson and McArthur two, and the others only one. Doctor Elliott of Boston gave a paper on resection of the liver before this Association in the '90's, about 40 years ago. Dr. Leonard Freeman reported on resection of the liver before this Association in 1904, 31 years ago. In the meantime, I have not been able to discover that there has been any report on resection of the liver.

This is a condition, then, which from the experience I have had within the few months I have been preparing this paper, has been impressed upon me as likely to occur in the practice of any man who does much abdominal surgery. In this connection, it is interesting to note that Doctor Finney had two cases, who appeared in his office on the same day and were operated upon on consecutive days. It is a condition, I believe, that is likely to occur in the experience of any man, and if you have not met with a tumor of the liver and have not been called upon to resect it, it is sometimes rather awkward. Some of you have had experience with the traumatic injuries of the liver and know they can bleed. Some of these cases do not bleed very much during resection. Others of them would bleed excessively unless properly handled.

So many cases have been brought to my attention since I started preparing this paper that I intend to send out a questionnaire to the members of the Association, to determine how many have had experience with tumors of the

liver. Evidently only a small proportion of the tumors that have been operated upon have been reported, and it is occurring in practice without previous experience, more or less of an emergency situation.

Regarding Doctor Beer's comment: I looked up all the references that were available in the Surgeon General's Index Catalog and the Cumulative Index, but the way that the tumors of the liver are indexed makes it difficult to find them in some instances. Many references were accidentally found and were not among the regularly listed reports of liver surgery.

As regards the regeneration which Doctor Rixford has spoken of, I mention in the paper that up to three-fourths of the liver has been removed experimentally by a number, the latest being Fishback of the Mayo Clinic, who found that the liver regenerated, after four-fifths had been removed, in from six to eight months.

CONGENITAL OBSTRUCTION OF THE BILE DUCTS

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THIS paper is based on a study of 45 cases of congenital obstruction of the bile ducts occurring in the Children's Hospital of Boston.

According to Yllpo¹ and other observers, the bile ducts in their process of development pass through a solid stage analogous to that of the intestine. That is, the lumen of the ducts becomes obliterated by epithelial concrescence or proliferation. If normal development continues, this solid cord becomes vacuolated, the vacuoles coalesce, and the lumen becomes reestablished. An arrest in development during the solid stage more adequately explains the malformations found than any of the other theories advanced. The cause of the arrest in development still remains a matter of surmise.

The gross pathologic findings associated with these obstructions of the biliary ducts are a general icterus of all the tissues of the body, an enlarged liver with increased firmness to touch and an irregular pebbly surface of darker color than normal, and a wide variation in the malformation of the ducts (Figs. 1 and 2).

Microscopically, one finds in the liver a marked interlobular and intra-lobular fibrosis with slight round cell infiltration in some cases. The bile capillaries are plugged with greenish-black inspissated bile. The liver cells contain small granules of bile pigment. Particles of bile pigment are also found in phagocytic cells of the small capillaries in the interstitial fibrous tissue. In short, the liver presents the picture of bile stasis and biliary cirrhosis (Fig. 3). The pathologic findings in other parts of the body are not remarkable.

In 1916 Holmes² collected 120 cases from the literature and described a large number of variations in the malformations. While it is true that almost no two cases are exactly alike, still for practical purposes it is possible to classify these malformations into a small number of groups.

- (1) Cases in which there are no extrahepatic ducts.
- (2) Cases in which there is an atresia of the hepatic ducts.
- (3) Cases in which there is an atresia of the common duct.
- (4) Cases in which the gallbladder is represented by a moderate sized cyst not connected with the common duct and in which there may or may not be any common or hepatic ducts.
- (5) Cases in which the gallbladder connects directly with the duodenum but in which there are no other extrahepatic ducts. That is, no ducts connect the liver and gallbladder or the liver and intestine.
- (6) Cases in which there is a stenosis of the common duct plugged with inspissated bile causing complete obstruction.

- (7) Cases in which there is narrowing of the common duct causing partial obstruction.

The diagnosis of congenital obstruction of the bile ducts may be quite difficult to make in the first few weeks of life but it becomes simpler as the infant grows older. The jaundice may be present a few days after birth but does not become marked until the infant is two or three weeks old. As the infant enters the second month of life the jaundice becomes more intense but of a greenish-yellow tinge rather than the marked yellow seen in biliary obstruction of adult life. The stools are acholic as a rule but may at times give a positive test for bile or show gross evidence of bile on their surface even in the cases of atresia or complete absence of extrahepatic ducts. This



FIG 1.—Shows cut surface of the liver. Note the fibrous tissue interspersed throughout the parenchyma and the dark color due to bile stasis.

phenomenon is explained by the fact that the bile is carried by the blood stream to the mucosa of the intestine and excreted by it into the lumen of the gut. The urine is dark colored and gives a positive test for bile. The icterus index is very variable in different patients and from day to day in the same patient and in our series has ranged from 50 to 200. This test compares serum with potassium bichromate 1-10,000 as the standard 1, and then compares the serum with the solution in greater concentration. The bleeding and clotting time may be slightly prolonged but no great variation from the normal has been found in this series. The fragility of the red cells is not abnormal nor is there a marked increase in erythroblasts. A red count and hemoglobin below normal have been observed in some of the patients. One

expects to find a positive direct van den Bergh reaction and no increase on the addition of alcohol. In other words, there is not a biphasic reaction. On physical examination these patients show a surprisingly good state of general nutrition and development even when several months old. The striking features are the general icterus and the enlarged liver with a very firm or hard edge.

The diseases of infancy with which congenital obstruction of the bile ducts might be confused are:

Icterus neonatorum is not a serious condition and usually has disappeared by the end of the second week of life. During the first two weeks after birth, however, the infant may present a very similar amount of icterus to the infant

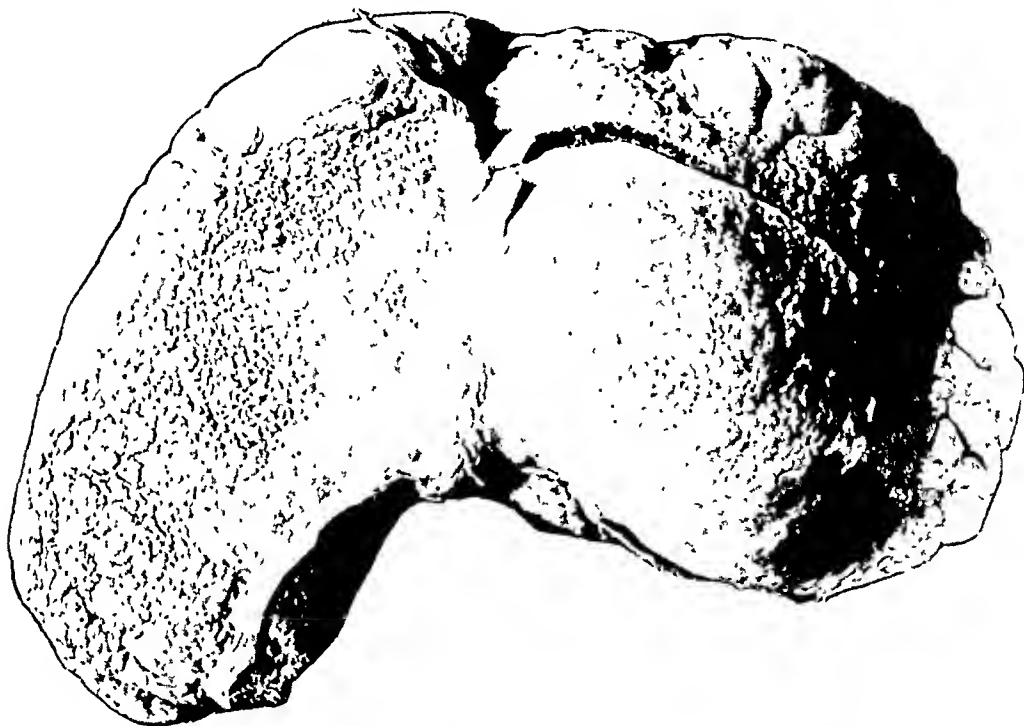


FIG. 2.—Outer upper surface of the same liver as Fig. 1 showing pebbly appearance present with marked degree of obstructive biliary cirrhosis.

with obliteration of the bile ducts. Such an infant does not present the enlargement of the liver, the acholic stools, or bilious urine found in the cases of biliary obstruction. These factors and time will remove the possibility of confusion between these two conditions.

Erythroblastosis, sometimes classified under the name of *icterus gravis*, may present a clinical picture simulating that due to biliary obstruction. The jaundice may be of like intensity and the liver show an equal or greater enlargement. In this condition it is common to have an associated splenomegaly. Clifford and Hertig,³ Diamond, Blackfan, and Baty,⁴ have mentioned the finding of a marked golden vernix caseosa and a hypertrophied placenta as important factors in making one suspect the presence of erythroblastosis. These conditions should be considered as indications for further investiga-

tion of the patient rather than factors in making the diagnosis. The finding of an increased number of erythroblasts on successive blood examinations is an important factor in differentiating this disease. In erythroblastosis one expects to find a positive biphasic van den Bergh reaction. The positive direct reaction is due to the great increase in the hematopoietic centers in the liver and the biphasic reaction to the breaking down of the red cells. This condition is associated with a very high mortality in the first few days or weeks of life so that the chance of confusing it with malformation of the bile ducts becomes progressively less as time elapses. The treatment of erythroblastosis is multiple transfusions which yield a fair percentage of cures.

Jaundice of hemolytic sepsis may resemble that due to bile stasis and one might be confused, without careful study, by the fact that small infants

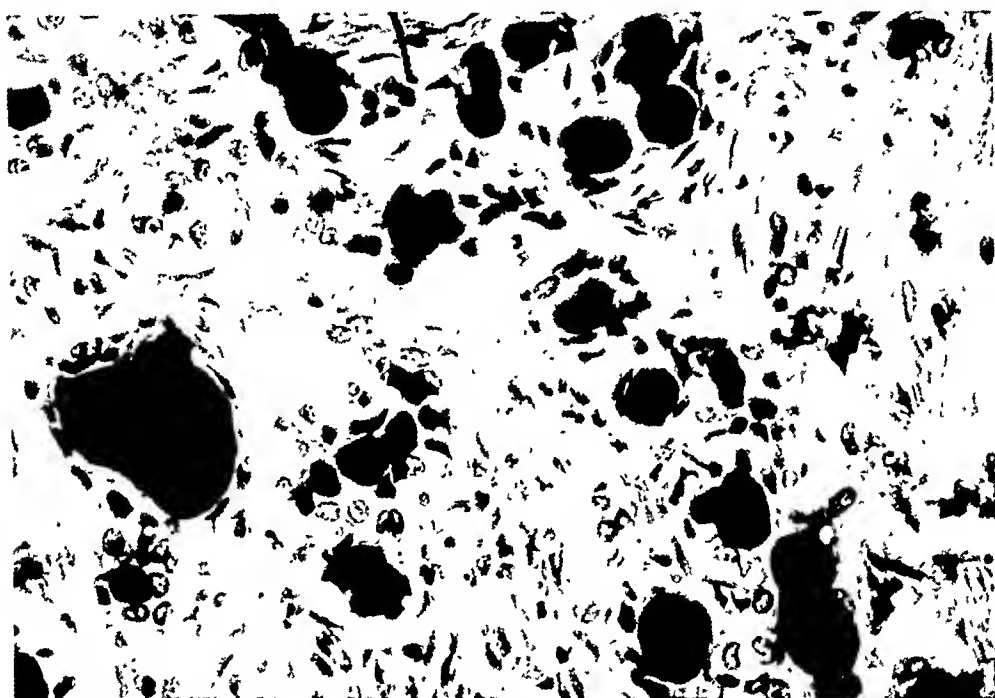


FIG. 3.—Photomicrograph of liver from a case of congenital atresia of bile ducts. Note dilated bile capillaries filled with black inspissated bile, and marked increase in fibrosis.

may be suffering from marked sepsis without showing a febrile reaction and also by the not uncommon enlargement of the liver with infection. Acholic stools, bile in the urine, a high icterus index, or progressively increasing jaundice are not seen in patients with sepsis.

Congenital syphilis should be mentioned in the differential diagnosis and in case of doubt investigated by a careful maternal history, a Wassermann reaction of mother and child and roentgenologic studies of the long bones of the child.

As a rule of thumb it may be stated that if one delays making a final diagnosis of congenital biliary obstruction until the infant is a month or six weeks old the chance of error is not great.

When one has made the diagnosis of congenital obstruction of the bile ducts exploratory operation is the obvious next step, as 100 per cent mor-

mortem examination confirmed my operative findings and was identical with the autopsy observations in the first case. These two patients had gallbladders but no extrahepatic ducts. The obvious lesson to be drawn from these two patients is that one should have good evidence of the gallbladder connecting with the liver before anastomosing it to the intestine.

Recently I explored a jaundiced infant (Case No. 167813) referred from Scranton, Pa. (Fig. 6). The usual procedure of inserting a catheter into the gallbladder and injecting saline to assist in identifying the ducts was followed. There was slight resistance to the injection at first and the saline then readily passed into the duodenum. It was felt that there had been a plugged duct which had been relieved. The patient made no improvement

after operation and at a second operation the condition which should have been recognized at the first was found. The gallbladder connected by the common duct directly to the duodenum. There was no hepatic duct. Simmonds⁵ has reported two and Ashby⁶ one identical case found at autopsy.

A three months old baby (Case No. 149320) was explored. A rudimentary gallbladder without patent cystic duct was found. What was thought to be the blind end of the common duct was identified and opened but no bile was apparent. A small catheter was tied into this and led out through the abdominal wound. There was profuse flow of bile through the catheter the next day. Two days later the wound was reopened and an end-to-side anas-

tomosis performed over too long a piece of rubber catheter. The post-operative convalescence was very satisfactory. Bile appeared in the stools and disappeared from the urine and the jaundice cleared, but the piece of catheter over which the anastomosis had been made was not passed. Two months later the baby developed signs of fluid in the abdomen and later evidence of pneumonia and died. Probably a third operation should have been performed for removal of the rubber tube. My theory was that the upper end of the tube had ulcerated through the bile duct allowing bile to escape into the peritoneal cavity and that the pneumonia was a terminal affair. The theory could not be proved as permission for autopsy was not granted.

A month old patient (Case No. 156370) was explored and no extrahepatic ducts found. Later at postmortem examination an atresia of the common duct was identified which could have been anastomosed to the duodenum. This case is included among the operable group.

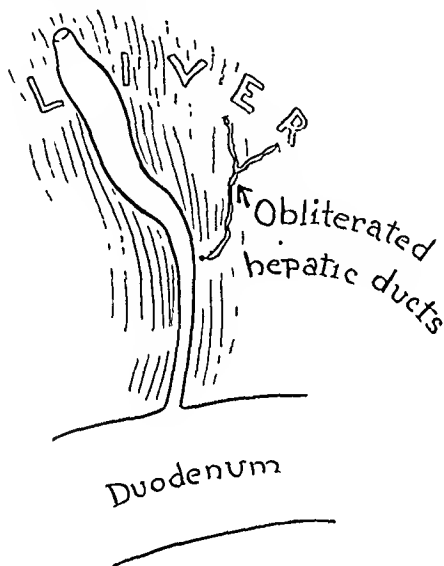


FIG. 6.—Case No. 167813.—Case in which the gallbladder was connected to the duodenum but in which the hepatic ducts were obliterated and there was no connection between either the liver and the duodenum or the gallbladder and the liver.

PROGNOSIS

It is of course apparent that if there is a malformation of the bile ducts which prevents bile from entering the intestinal canal, the condition is incompatible with life. The surprising fact is the length of time which an infant can live with such a condition. In this series of 45 cases one patient with atresia of the hepatic ducts lived to the age of twelve months when he died of intraperitoneal hemorrhage. Another infant died at the age of ten months shortly after an exploratory operation had revealed the absence of extrahepatic ducts. The average duration of life was four and one-half months in five patients, all of whom had inoperable conditions not explored. In 20 patients who were explored and found to have inoperable conditions the duration of life was five and one-half months.

From the study of these cases one may deduce, therefore, that although an occasional infant may live for many months without bile entering the intestine the majority die within six months and some sooner. For this reason it is obvious that exploration should be resorted to before the fourth month of life.

Of the remaining 20 patients in this group all were explored and found to have conditions theoretically amenable to surgical treatment. They may be classified according to the malformation found and whether the obstruction was complete or not.

There were 15 cases in which the obstruction was complete and five in which the obstruction was partial.

Of the 15 cases in which the obstruction was complete five were due to plugging of a stenosed common duct with inspissated bile. These were all treated by the operation, mentioned earlier in the paper, of distention of the ducts with salt solution or with a probe. All were operated before the third month of life. Four of these patients recovered and were discharged from the hospital apparently well. One of them is reported to be in perfect health ten years, and one eight years after the operation. The other two have not been followed for so long a period of time but at last note were in excellent health. The one patient of this group who died was discharged from the hospital apparently well but died within two months and at autopsy the ducts were found to be replugged.

Six patients with atresia of the common duct were operated on under two and one-half months of age. Four recovered and two died. Of the four who recovered two had a choledochoduodenostomy done over a short piece of rubber tube, one a choledochoduodenostomy over a catheter introduced through the gallbladder, cystic and common duct, and one had a cholecyst-gastrostomy. These patients have been followed for nine years, six years, nine months, and six months respectively and all appear to be in excellent health.

There were five patients with atresia of the hepatic duct. Of these, one patient, on whom an hepaticoduodenostomy was performed with the same technic used in the common duct atresias, recovered and has been re-

ported free of jaundice and in excellent health at the end of two years. One patient made an excellent immediate postoperative recovery but died four months later. One patient who had been allowed to go to seven months of age died 48 hours after operation with symptoms suggesting hemorrhage. No autopsy was performed. One patient died at 12 months of age without being explored and one who was explored died at six months of age, a month after operation. In this last case no patent ducts were found at operation but a hepatic duct theoretically capable of being anastomosed was found at autopsy. It may be seen from these five cases that in our clinic at least the outlook in cases of hepatic duct atresia is less favorable than in common duct atresia. It also may be suggested that these cases offer possibilities of better results than we have obtained.

Five cases of partial obstruction have been included in this series as it is believed that they were due to congenital malformation of the bile ducts even though the symptoms did not all become apparent in the first weeks of life. However, the patients whose jaundice appeared later presented the same findings at operation with those that were found in the patients who were jaundiced in the first weeks of life. The youngest of these five patients was operated on at the age of two and one-half years and the oldest at five years. The operation of cholecystoduodenostomy was performed on three of the patients and that of choledochoduodenostomy on two. There was no mortality in this group which has been followed for periods of one month to 15 years. Though there was no mortality in the group the results have not been entirely satisfactory. The patient who has been followed the longest, namely 15 years, has mild attacks of jaundice from time to time. None of the other four who have been followed for periods of seven years, five years, four months, and one month respectively have had any recurrence of their jaundice. They have had occasional attacks of mild abdominal pain or discomfort. One patient on whom a choledochoduodenostomy was performed has had no recurrence of jaundice and the pain referred to has been so slight and so fleeting as to hardly warrant comment. The other patient on whom choledochoduodenostomy was performed was followed too short a time to justify definite conclusions, but both suggest that the operation of choledochoduodenostomy is preferable to that of cholecystoduodenostomy.

CONCLUSIONS

Obstruction of the bile ducts due to congenital malformation is certainly common enough to warrant more attention in the future than it has received in the past.

The diagnosis can be made by a process of elimination with great certainty by the end of the second month of life, and usually a little earlier. When the diagnosis has been made, exploratory operation should be recommended. The mortality of the patients with complete obstruction without operation is obviously 100 per cent. In this series of 45 cases, there were 40 cases with complete obstruction. Of these 40 cases, 15 were theoretically amenable to relief

by surgical methods. In other words, 37 per cent of the cases present possibilities of cure. Nine patients or 60 per cent of the operable patients with complete obstruction have recovered, and have been followed for periods of time ranging from ten years down to six months. They have remained free of jaundice, and developed normally. From this experience, it seems justifiable to conclude that the liver has sufficient regenerative power to overcome the fibrosis which was observed at the time of operation. It likewise seems reasonable to believe that the idea that these patients are going to die of this cirrhosis even after the obstruction has been relieved is unwarranted. The operation should be done before the fourth month of life because the patients are prone to suffer fatal complications after that age. The group in this series having partial obstruction have had no mortality. In this group, the late results suggest that the operation of choledochoduodenostomy is preferable to that of cholecystoduodenostomy.

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STENOSIS OF THE BILE DUCTS BY CONTIGUOUS CICATRICIAL TISSUE

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STENOSIS usually connotes a narrowing of either extremity of a canal or of an intervening segment the result of some inherent lesion. The fact that the title of this paper refers to the canals in question—namely, the bile ducts—as normal, ought to prevent misunderstanding. Perhaps obstruction in place of a stenosis would be preferable.

Strictly speaking, in two cases herewith reported, the bile ducts were not normal. Thus in Case VI some thickening of the wall of the common duct underlying the adhesion was found, and in Case VIII the middle of the common duct was considerably dilated and somewhat thickened by adhesion. In both instances the thickening was evidently limited to the outer wall of the duct, representing the extension of the contiguous cicatricial tissue. A similar condition is frequently observed in other abdominal viscera adherent to some primary infectious process. Inspection of the mucous membrane of the divided duct can alone determine the presence of some pathologic change. Such an opportunity was afforded in Case VII, no mention being made of any lesion in the lining membrane of the duct. In this and all other reported cases the relief of symptoms and the absence of recurrence seem to justify the conclusion that the ducts were essentially normal.

Jaundice due to the pressure on the normal hepatic or common ducts by some extraneous lesion is not uncommon. It may follow the pressure of lymphatic glands at the hilus of the liver, involved in ordinary inflammation or of those invaded by tuberculosis or carcinoma, the pressure of cysts in the kidney or liver, including those due to the echinococcus; by the pressure of the gravid uterus; or the blocking of the duct with the ascarides. The closure of the duct of Wirzung by the pressure of malignant growths in the head of the pancreas is not infrequent. While the common duct cannot be regarded as normal in the two cases reported by Herfarth,¹ their great interest and rarity justify their mention at this time. In one, on autopsy several days after operation, the jaundice was found to have resulted from the invagination of the end of the duct into the duodenum, a transverse fold of its mucous membrane passing over and effectively closing its orifice. In the other, also on autopsy four days after an operation, jaundice had followed occlusion of the terminal duct through pressure on its orifice by a prolapse of its mucous membrane, projecting nipple-like into the lumen of the duodenum. The ages of the patients were 51 and 53 respectively, and in both cases some form of neoplasm was the preoperative diagnosis.

The present paper is not concerned with the different varieties of jaundice which have just been enumerated, but is restricted solely to the consideration

of stenosis of a normal biliary passage through the action of contiguous cicatricial tissue. If occlusion of the cystic duct alone results jaundice is not present. When the hepatic duct or common duct is involved, jaundice is constant and progressive.

While usually the formation of such adventitious tissue follows operation, it may, in the absence of operation, reflect the effort of the overlying peritoneum to protect the abdominal cavity against threatened perforation of the wall of some hollow viscus and, when so formed, such tissue may persist indefinitely, long after the infectious process, of which it originally was a part, has completely disappeared. Exceptionally in the upper right quadrant as in other parts of the abdominal cavity, bands or masses of connective tissue may form without the positive history of some previous infectious process. In one such instance in which abdominal discomfort had existed for many years and in which gastric stasis was relieved only by repeated daily lavage, the pylorus, hepatic flexure and gallbladder were found on operation completely invested in a mass of dense connective tissue. The pylorus was so sharply angulated and firmly attached to the under surface of the liver that only small quantities of gastric contents could pass into the upper intestine. Sharp dissection was necessary to restore the structures in the gastrohepatic omentum to their normal relation and to enucleate the gallbladder, entirely buried in the mass of connective tissue. No scars were found in the wall of either the pylorus or duodenum, indicative of previous ulceration and both the gallbladder and ducts were normal. Jaundice had never occurred notwithstanding the extensive pathology in and about the gastrohepatic omentum.

Peritoneal adhesions consisting of organized connective tissue either with or without previous abdominal operation vary in density and extent. In the upper right quadrant, especially after operation, they may be of almost cartilaginous consistency, and usually the anterior edge of the liver, the gallbladder, if present, the pylorus and first part of the duodenum, and the hepatic flexure are more or less firmly bound together in a mass of adherent great omentum. While no actual proof can be adduced and experienced pathologists may not concur, more dense and extensive adhesions seem to be encountered in the right upper quadrant than in the other segments of the peritoneal cavity. Especially subsequent to cholecystectomy or other operations on the biliary tract in which drainage has been extensive and protracted, these adhesions become organized into cicatricial tissue which, as it contracts distorts, constricts, or displaces those structures to which it may be attached. Angulation of the bile ducts, when these structures are distorted, no matter how slightly, may easily result in obstruction which it is difficult for the pressure of the bile current, which normally does not exceed four Mm., to overcome. Such angulation, following cholecystostomy, has been reported in an excellent essay by Stetten,^{3, 4} due to a postoperative shrinkage of the gallbladder. The consequent pain and discomfort, without jaundice, however, were relieved by a cholecystectomy. Apart from angulation or distortion of the duct, the presence of a biliary fistula is an important factor

in causing an almost complete absence of pressure in that portion of the duct between the orifice of the fistula and the intestine which, as long as the fistula persists, presents no resistance to any force of pressure or constriction to which it may be subjected. The result of angulation of the common duct is well illustrated in a case reported by Ransom,² in which, some weeks after a cholecystectomy, an attachment by cicatricial tissue of the divided end of the cystic duct to the under surface of the liver produced such an acute angle in the long axis of the common duct that persistent jaundice developed. The liberation of the cystic stump by the excision of the adherent tissue restored the normal axis of the common duct and permanently relieved the jaundice.

Perhaps it is well to emphasize at the risk of repetition that, because of the constant low pressure of the bile current, surprisingly slight degrees of obstruction may result in jaundice. In discussing this fact Doctor Rohdenburg, pathologist to the Lenox Hill Hospital, related a case, the history of which follows in which pinkish masses of apparently lymphatic tissue surrounding the end of the common duct and overlying one another in a somewhat spiral fashion, were found to have been the cause of the obstructive jaundice. He is of the opinion that a small probe should normally pass by its own weight through the papilla into the duodenum, provided it does not catch in a fold of mucous membrane. In the present case, on autopsy, such a probe passed through the papilla only with gentle pressure.

A female, aged 62, admitted to the hospital five months previous with jaundice. Operated upon and gallbladder with stones removed, drained. The common duct found patent at the time of operation. A fistula draining bile persisted for a time. The fistula closed and the patient became jaundiced. The fistula opened and the jaundice disappeared. This was repeated three times. She was discharged from the hospital with the fistula closed and slight jaundice one week before her death. She was readmitted with a right lower pneumonia from which she died seven days later. During her second stay in the hospital the fistula remained closed and the jaundice slowly became deeper. Death from cardiac failure.

Autopsy.—The region of the gallbladder is found to be a dense scar which is adherent to the overlying musculature and matting together the adjacent loops of the gastrointestinal tract. The liver is slightly enlarged, weighing 1,800 Gm., and is jaundiced. The usual markings are somewhat obscure. The liver and adherent intestinal canal is removed *in situ* and carefully dissected. The gut is opened and the duodenum identified. The ampulla of Vater is identified. The common bile duct is found. It does not appear to be dilated, measuring in the unopened state four cm. in cross section. Where the common duct enters the intestine and on the serous surface of the gut are found pinkish masses, apparently lymph nodes, which surround the common duct and which overlay one another in a somewhat spiral fashion. Upon opening the common duct at a distance from the intestine a four inch probe was easily passed into the intestine. Upon holding the liver up, the gut being suspended, the probe being in place, the probe did not fall into the gut through the ampulla.

The clinical records of the cases herewith reported are conveniently divided into two groups: A—Those in which no previous operation has been performed. B—Those in which such an operation has taken place.

GROUP A.—CASE I.—(Courtesy of Doctor Amendola). Multiple strictures of the cystic duct, due to adhesions from an old duodenal ulcer; marked cholecystitis without calculi. Distended gallbladder could be emptied only after division of adhesions. Cholecystectomy.

Male, aged 50. Treated previously for 15 years for duodenal ulcer with persistent ulcer defect. For past two years there have been symptoms suggesting gallbladder trouble without jaundice. The Graham test showed no change in emptying and no diminution in the concentration of the bile. Operation for the biliary condition. Through a pararectal incision the gallbladder was found to be distended and the site of a chronic cholecystitis. The cystic duct was angulated in several directions by adhesions which had extended upward from an old healed ulcer in the first part of the duodenum. As soon as these adhesions were divided the gallbladder could be easily emptied. The common duct was normal. A cholecystectomy was done.

CASE II.—(Courtesy of Dr. C. W. Cutler, Jr.). Adhesions about the ampulla of the gallbladder and around the cystic and common ducts from an old healed duodenal ulcer to the site of which the fundus and mid portion of the gallbladder were densely adherent. No calculi. Constriction relieved. Gallbladder not removed.

Male, aged 37. Chief complaint, right upper abdominal pain and indigestion. For three or four years the patient has suffered from indigestion, belching of gas associated with discomfort in the epigastrium and the right upper quadrant. There has been no definite relation of this pain to meals. Five days before admission there was a severe attack of right upper quadrant pain extending into the epigastrium. This pain was colicky in character and intermittent. It occurred in attacks of two or three hours' duration and was quite severe. The patient did not vomit. There was a similar attack two years ago.

Physical examination showed no masses, tenderness or spasm. Roentgen ray revealed a well visualized gallbladder which was, however, distinctly distorted about its mid portion. The stomach showed constant deformity of the duodenal cap with hypermotility and no retention.

At operation, the gallbladder in its fundus and mid portion was densely adherent to the first part of the duodenum by a thick short band of adhesions about one cm. in diameter and less than one cm. in length. The gallbladder wall about this adhesion was thickened. Upon freeing the gallbladder from the duodenum, the site of the adhesion was found to be the center of a puckered indurated area representing an old healed duodenal ulcer. There were also some adhesions about the ampulla of the gallbladder and around the cystic and common ducts. These constrictions were relieved. No stones were found. The gallbladder was not removed. A tab of fat from the mesentery was sutured across to cover the area of the former adhesions to the duodenum. Uninterrupted convalescence.

CASE III.—(Courtesy of Dr. C. W. Cutler, Jr.). Male, aged 31. Adhesions extending to gallbladder, cystic and common ducts from an old duodenal ulcer close to the pylorus with the history of one attack of jaundice. Symptoms permanently relieved by posterior gastro-enterostomy.

Chief complaint, pain in the right upper quadrant, recurring attacks of dyspepsia for 20 years. Several years ago the patient had an attack of typhoid fever of six weeks' duration. Some time afterward he suffered his first attack of right upper quadrant pain which was followed in several days by jaundice. Vomiting accompanied the attack. For several weeks afterward there was slight pain in the right upper quadrant. Since then he has had several similar attacks but without jaundice. Recently the pain has become more severe. There has been some relation of the pain to meals occurring one hour afterward, relieved by soda. A good deal of belching and feeling of distention. During the periods of remission he has felt perfectly well. Has noticed dark stools occasionally. No loss of weight.

Physical examination revealed tenderness in the right upper quadrant, no palpable mass but a sense of fullness. Roentgen ray showed evidence of duodenal ulcer.

On operation the gallbladder was found adherent to the duodenum. In the duodenum was an old constricting ulcer close to the pylorus with adhesions extending to the gallbladder, the cystic and common ducts. A posterior gastro-enterostomy was done. Recovery satisfactory.

CASE IV.—(Courtesy of Dr. R. H. Patterson). Female, aged 26. Constriction of the supraduodenal portion of the common duct to one fifth of its caliber by a band of fibrous tissue extending from the first part of the duodenum to a shriveled and puckered gastrohepatic omentum, containing a good sized branch of the gastroduodenal artery. Intermittent jaundice. After the division of the band and the ligation of the artery the caliber of the duct became normal and bile readily passed into the intestine. During the past two years patient has had intermittent attacks of pain in the right upper quadrant often associated with jaundice. The pain has never been agonizing nor the jaundice severe. Gallbladder and G. I. series negative. Lyons drainage has failed to yield any "B" bile. Otherwise essentially negative.

On operation through right rectus splitting incision, the gastrohepatic omentum was very short and puckered up, bringing the pylorus and the first part of the duodenum much closer than usual to the gallbladder. From the upper border of the first part of the duodenum a fibrous band, containing an artery, extended to and encircled the right lateral and posterior aspects of the lower third of the common duct in such a way as to rotate or twist or constrict the duct until it was not more than one-quarter or one-fifth of its normal diameter. When the gallbladder was compressed it would not empty.

The peritoneum covering the gastrohepatic omentum was divided transversely and the vessels and duct straightened out considerably. The fibrous band and its artery were then ligated and divided. The duct then returned nearly to its normal diameter and pressure easily emptied the gallbladder. The patient made an excellent recovery and, now, at the end of two years, there has been no sign of recurrence.

GROUP B.—CASE V.—(Courtesy of Dr. C. W. Cutler, Jr.). Female, aged 62. Five months previous to the present illness a cholecystectomy was performed. For past three weeks pain in the right upper quadrant with gradual increasing jaundice. On operation there were numerous extensive adhesions between liver, omentum and duodenum. Adhesions divided. No stone in the common duct. Moderate chronic infiltration of the pancreas. Death from cardiac failure four days later.

CASE VI.—(Courtesy of Dr. C. W. Cutler, Jr.). Male, aged 73. Ten years ago a cholecystectomy. For past three weeks pain in the right upper quadrant with increasing jaundice. On operation adhesions constricting the common duct with some thickening of its wall underlying the adhesions were found. Adhesions divided. No stone in the common duct. Discharged in good condition four weeks after operation.

CASE VII.—(Courtesy of Dr. C. W. Cutler, Jr.). Female, aged 49. One year ago cholecystectomy and choledochotomy for calculi. For past week nausea, vomiting, epigastric pain, and jaundice. Common duct found greatly dilated and kinked at its lower end where it was adherent to the superior surface of the duodenum. Pancreas soft. Common duct freed and drained. Recovery.

CASE VIII.—(Courtesy of Dr. DeWitt Stetten). Female, aged 41. Cholecystectomy in 1920. Four years later severe pain in the epigastrium (requiring morphine) with vomiting and jaundice. On operation extensive adhesions (not very dense) between omentum, ascending colon, hepatic flexure of the colon and loose coils of ileum to the anterior abdominal wall, and to the under surface of the liver. The duodenum was adherent through dense adhesions to the under surface of the liver near the transverse fissure, causing marked angulation of its axis. The middle of the common duct was considerably dilated and somewhat thickened by adhesions. No calculi were found.

There was marked induration of the pancreas. All adhesions were freed. The duct was not opened. Recovery satisfactory. No recurrence.

PERSONAL CASES

CASE IX.—Female, aged 52. Cholecystectomy in 1905 for biliary calculi. At that time the ducts were normal. Nine months later pain developed in the right upper quadrant with gradually increasing jaundice. At operation dense adhesions between the liver, the hepatic flexure, pylorus and omentum were found, kinking the common duct. The adhesions were freed and the abdomen closed without drainage. The jaundice disappeared and the patient remained well for 18 years when death due to apoplexy occurred.

CASE X.—Male, aged 56. Eight years before present illness cholecystectomy for gallstones. Five weeks ago jaundice appeared without pain and has steadily deepened. In the last few months he has lost 20 pounds in weight. On operation firm and dense adhesions between the liver, stomach, duodenum, the hepatic flexure and omentum were found. By sharp dissection these adhesions were gradually divided until the gastrohepatic omentum was exposed. The vessels and duct, the latter without calculi, were restored to their normal relations. Normal bile was withdrawn through a fine needle from the interior of the duct. The head of the pancreas was thick and firm without any distinct new growth. A small overlying lymphatic gland removed for microscopic examination, showed ordinary inflammatory changes. Closure without drainage. The jaundice disappeared entirely within six weeks. The patient regained the lost weight, and has remained well up to the present time, two and one-half years since the operation.

That contraction of cicatricial tissue completely investing the hepatic or common duct ought eventually to obstruct the flow of bile is quite conceivable. In that event the simultaneous inclusion of the adjacent portal vein and its subjection to the same constricting force might logically be expected. The fact, however, that that important vessel is rarely sufficiently constricted to disturb the portal circulation or to result in ascites, justifies the conclusion that the obstructive jaundice in these cases is ordinarily due to angulation or distortion rather than to annular constriction of the duct. As a matter of fact the actual cause of obstruction can rarely be demonstrated in the course of the operation for its relief, for the offending tissue must be divided, not infrequently by sharp dissection, in order to restore the gastrohepatic omentum and its contents to their approximately normal relations.

Furthermore, consideration of the anatomic and physiologic features of the duct and vein may account, in part at least, for the rarity of obstruction to the portal circulation irrespective of the character and extent of the cicatricial tissue. Thus, the diameter of the lumen of the portal vein is twice that of the duct. Its wall contains a large amount of longitudinal smooth muscle, abundant fibrous tissue, and a small amount of elastic tissue. In the relatively thin wall of the duct, there is a large amount of elastic tissue, scant longitudinal muscle fibers, and little fibrous tissue. The lumen of the duct is easily occluded by external pressure and may be completely occluded by an external annular cicatrix. Owing to its larger diameter and inelastic wall, such an annular cicatrix would merely pucker, without occluding the lumen of the vein. The relation of the hepatic artery to the portal vein is an important contributing factor to the relative immunity the vein enjoys in the occlusion of its lumen by the contraction of contiguous cicatricial tissue. In its

course from below upward the vein lies first on a posterior plane between the artery and the duct, as it approaches the transverse fissure of the liver it passes behind the artery and overlaps it internally, the distance between the duct and the vein gradually increasing. The artery is in fact a quasi-mechanical factor protecting the vein from encroachment by adhesions, while the intravenous pressure as well as the velocity of the blood within the vein by the transmission of the intra-arterial pressure are materially increased.

Although unable to find in surgical literature the report of the occlusion of either the normal duct or normal vein by cicatricial tissue, the cases just cited show conclusively that obstructive jaundice due to that cause is not rare. On the other hand, only one instance of obstruction to the flow of blood within the portal vein due to a similar cause is available.

CASE XI.—(Courtesy of Doctor Rohdenburg). Clinical history not found. Autopsy record: the gallbladder had been removed at a previous operation and the first and second parts of the duodenum are firmly attached to the inferior surface of the liver in the space originally occupied by the gallbladder. This mass of fibrous tissue is adherent to the adjacent lumbar vertebrae and the great vessels and is found constricting the portal vein. The latter shows no evidence of thrombosis. In this case there was extensive ascites but no jaundice. The liver showed a marked passive congestion.

In the following case the stenosis of the portal vein was probably only a contributing factor in the development of the ascites. The multiple infected thrombi in the portal radicals, together with the absence of congestion in the liver, the spleen and the alimentary canal justify that conclusion. The case has, however, marked pathologic interest for, as in Doctor Rohdenburg's case, it demonstrates the possibility of stenosis of the portal vein without involvement of the duct. In this, as well as in the preceding case, jaundice was absent.

CASE XII.—(Courtesy of Doctor Stetten). Female, aged 29. Cholecystectomy for a dilated and tense gallbladder without calculi. Convalescence marked by rapid pulse, and by some congestion over the bases of both lungs. There was also pain in the dorsolumbar region suggestive of renal calculi, but roentgen ray excluded both that lesion and any abnormality in the upper intestinal tract. Three months after the cholecystectomy, patient was readmitted to the hospital with abdominal discomfort and pain extending from the dorsolumbar region around to the pubis. Cystoscopy was negative.

On examination, the liver was found to be greatly increased in size and on two occasions considerable fluid was withdrawn from the abdominal cavity. After two months of observation in the medical ward the abdomen was explored. The stomach, duodenum, hepatic flexure and omentum were bound together by firm and very dense adhesions. As the transverse fissure of the liver was approached, these adhesions became almost of cartilaginous consistency. An effort was made to expose the portal vein without success. The liver was large and friable, the spleen of normal size and consistency. The patient did well for ten days and then suddenly developed a high temperature and rapid pulse and shortly died in a condition of collapse. A partial examination made through the operative wound showed stenosis of the portal vein by the cartilaginous tissue at the transverse fissure of the liver without thrombus formation. Sections of the liver and kidney showed the presence of a large number of infected thrombi of which mention has previously been made.

It is important to emphasize that the clinical histories of these cases of duct obstruction vary considerably. This is particularly true of the associated pain and jaundice. The former symptom, usually present and generally referred to the upper right quadrant, may be referred to the "pit of the stomach" or to the epigastric region. It may be localized or diffuse, so severe as to require morphine, or may be only a sense of discomfort. In Case X there was no pain at any time and that fact, together with the noticeable loss of weight in a patient over 50, suggested a malignant condition. The variation in the type and location of this symptom is also observed in the more common lesions of the biliary tract. Not infrequently calculi in the common duct are painless or are absent when the pain is severe. Jaundice also varies. It may be intermittent, or constant and progressive. It may be due to inflammation of the mucous membrane of the duct and not to stenosis.

While division or excision of the offending cicatricial tissue ordinarily affords relief, which in several of the cases cited continued for years without any indication of recurrence, reformation of similar adhesions with stenosis or distortion of the duct is not impossible. Should it occur, operation is of course again indicated.

Great appreciation is expressed to Doctors Amendola and Cutler of Roosevelt Hospital; Doctor Patterson of Bellevue Hospital; Doctors Rohdenburg and Stetten of the Lenox Hill Hospital; and to Doctors Prewitt and Helfrick of the Knickerbocker Hospital for their kind cooperation and assistance.

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DISCUSSION.—DR. DANIEL F. JONES (Boston, Mass.).—After considering some 2,000 operations I could not find any case in which the condition found in these cases was present. Our pathologist told me that he knew of one case of obstruction to the common duct due to a tuberculous node, which condition Doctor Eliot has not considered.

It seems to me that these cases fall into two groups. The first group includes the obstructions to the cystic duct, while the second includes kinks or bands obstructing the common duct. In the first group it is quite easy to see that the cystic duct is freely movable and therefore might be obstructed by a band which pulled upon it enough to obstruct it, but this must be very unusual.

The condition in the second group, obstruction to the common duct by bands or adhesions, would seem impossible so long as the duct is covered by peritoneum. A band attached to the peritoneum over the duct could not, I believe, kink the duct. It might be possible in drained cases to have the stump of the cystic duct become adherent to a gauze drain, and one can imagine the stump of the duct being so pulled upon when the drain is removed that the common duct is kinked and the kink maintained by the cystic duct which becomes adherent in this abnormal position. An inflammatory process about the common duct, if it is covered by peritoneum, will I believe never cause obstruction. If the peritoneum is destroyed and the inflammatory

process of long standing, it is probably possible for it to cause obstruction.

The importance of this communication, it seems to me, is to bring out the fact that the common duct may be partially obstructed when left uncovered, and that the duct should always be covered with peritoneum after it has been exposed. Care must also be used to prevent the wick becoming adherent to the stump of the cystic duct as it might be pulled up sufficiently to kink the common duct. I have, however, been unable to find any such case. I could find no case in which an adhesion or any inflammatory process outside the duct, except in the pancreas, had caused obstruction to the common duct.

DR. CONDUCT W. CUTLER (New York).—We are indebted to Doctor Eliot for presenting, in this paper, a feature of real though perhaps previously underestimated importance in the pathology of the biliary tract. In his cases, described in Group B, representing instances of constriction of the bile passages by adhesions following operation on the gallbladder we are reminded of a possible late complication of cholecystectomy. It seems reasonable to suppose that some of the right upper quadrant pain and epigastric distress to which patients, who have had a cholecystectomy, are occasionally subject, may be explained by the presence of such constricting or distorting adhesions as he has described. Fortunately, in most instances the viscera adjust or accommodate themselves to the situation and the symptoms abate after a time. In comparatively few the condition persists to the point where further surgery is required as in the cases cited.

It would seem important to consider means of minimizing the formation of such adhesions. This brings into practical consideration the matter of peritonealizing of the gallbladder bed, the question of drainage after cholecystectomy, and of care in the protection and packing off of neighboring viscera and in their handling during the operation. In recent cholecystectomies at the Roosevelt Hospital I have used rubber dam, as suggested by Lilienthal, for packing off the field, as being less traumatizing to peritoneum than gauze pads.

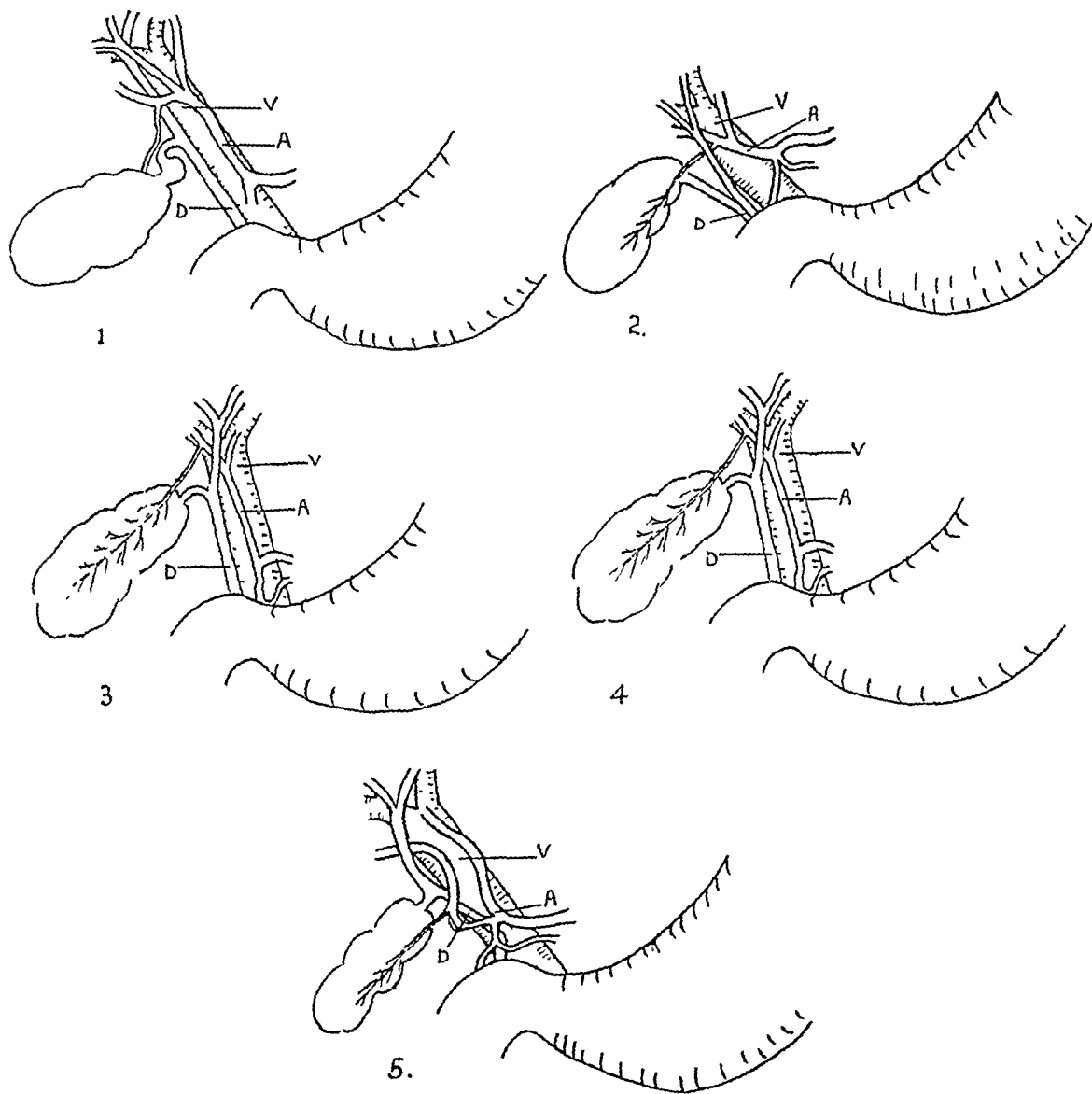
In Doctor Eliot's Group A cases we have an interesting illustration of distortions of the biliary tract by adhesions from pathology in neighboring structures. These distortions are truly pathologic and productive of symptoms, and are not to be confused with such anatomic and congenital anomalies as have been recently described by Boyden.¹ The roentgenograms of the two conditions are much alike. These anomalous distortions of the fundus and body of the gallbladder, which have also been described by Barsony and other German writers, were found by Boyden to be present in four per cent of 165 cases examined. Buedinger² has grouped these congenital anomalies and the pathologic distortions together in his description of cholecystitis mechanica. It would seem well to recognize the distinction as of importance from the therapeutic point of view.

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DR. ELLSWORTH ELIOT (New York).—I am very much indebted to both Doctor Jones and Doctor Cutler for the discussions they have contributed. I regret very much that Doctor Cave, who had also promised to dis-

cuss the paper, was called back to New York. He would have emphasized the fact, which I also venture to emphasize, that the excision of the cicatricial tissue only will not always relieve the patient. He intended to report a case in which the cicatricial tissue was so dense that an anastomosis between the dilated duct above the cicatricial tissue and the duodenum was necessary. This anastomosis was performed with a Murphy button. The patient made an excellent recovery and, four years after that operation has had no recurrence. Doctor Cave was also to report a case following a cholecystectomy in which the cicatricial tissue was removed in the way which has been cited



Doctor Helfrick's sketches, showing relation of hepatic artery, portal vein, hepatic and common duct.

in the paper, with an equally satisfactory result, the recovery extending five years after the operation without recurrence.

As to the frequency of this condition, I think it is rather of interest to call attention to the fact that I was unable to obtain a report of a single case from members of this Association in Cleveland, Boston, Philadelphia, Baltimore, Rochester, and one or two other centers, nor from several colleagues in New York whose experience in the surgery of the gall ducts has been very extensive.

I wish also to emphasize the necessity in this condition, mentioned by Doctor Jones, of careful, gentle handling, and by Doctor Cutler, the advisa-

bility of the use of the rubber pad, and by Doctor Cave, were he present, the interposition of the omentum between the under surface of the liver and the upper surface of the duodenum, all measures which may possibly restrict the formation of cicatricial tissue and so diminish the frequency of this condition.

The following five slides made from sketches in the course of autopsies, without previous injection of the vascular channels and ducts, there by preserving the normal relation of these structures, in patients with normal abdominal cavities who had died from the effects of severe trauma. For their preparation I am indebted to my intern Dr. R. Helfrick at the Knickerbocker Hospital. In all of them, A designates the hepatic artery; B the portal vein; and D the common duct. They illustrate both the normal relation and the not infrequent variations of the hepatic artery and its branches and require no detailed description. All show the tendency for the vein to pass behind and to the mesial side of the artery as it approaches the liver, diverging slightly from the duct, as it ascends along its side.

TREATMENT OF CARCINOMA OF THE AMPULLA OF VATER

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A DEFINITE advance has been made in the last five or six years in the surgery of the pancreas, notably in the brilliant cures of hyperinsulinism by the removal of adenomata and more recently by the excision of a large part of the pancreas itself. These cures have been reported by American surgeons with no mortality in the series thus far published.

Because of a technique used in successful operations on a number of adenomata, cyst-adenomata and benign cysts of the pancreas, we became interested again in attacking the problem of malignancy of the pancreas and peri-ampullar region. The fact that a large part of the pancreas can be safely excised, and that in animals the main ducts can be ligated as they enter the duodenum without permanent damage to their well being, suggested a new approach to the problem. This was impressed upon us after an unsuccessful attempt to remove a carcinoma of the ampulla of Vater by the transduodenal method.

Involved in the previous attempts at radical removal of carcinoma of the papilla of Vater and the head of the pancreas are certain factors which have compromised its success and made it such a hazardous procedure as to be prohibitive in the minds of even the ablest surgeons. The first of these was the mistaken belief that the flow of pancreatic juice is essential to life, which led surgeons to attempt to reestablish this flow into the duodenum or jejunum by implanting the resected head of the pancreas or the cut end of the duct into the upper intestine. The activation of the pancreatic ferments by duodenal contents compromised any type of anastomosis in the human subject, especially around the posterior aspect of the duodenum devoid of peritoneum. Experimentally the operation of pancreato-enterostomy has been done successfully in dogs by Sauv ,¹ Coffey,² and Sweet.³ However, in dogs the pancreas is mobile and covered by peritoneum, quite in contrast to man. There are four case reports in the literature (Halsted, Hirschel, Kausch, Tenani⁴) in which this operation of reimplantation of the head of the pancreas or the duct was successfully carried out after a resection of the carcinoma of the ampulla. Two others reported by Koerte and Mayo-Robson died following this procedure. Our patient operated upon in this manner died from leakage around the anastomosis. We can form no idea of the number of unpublished cases in which it has been tried and resulted fatally, but it has seemed to us, because of the digestive action of the pancreatic ferments, that the hazard of this operation is too great to be advocated.

The second factor was the attempt to carry out the excision of these

tumors in one stage, whatever the method used. The victims of these tumors are as a rule deeply jaundiced, have a hemorrhagic diathesis, are depleted, undernourished, asthenic, and have severe liver damage. The majority of these patients cannot survive such a major operation until the associated conditions have been relieved. This factor has been recognized in recent years, and a preliminary short-circuiting operation to relieve jaundice has been carried out.

As a result of mistakes which were made in operating on our first two cases we arrived at a technic for radical removal for carcinoma of the papilla or the peri-ampullar region embodying the following principles:

1—That after resecting the descending limb of the duodenum with the pancreas wide of the growth no attempt should be made to reestablish the continuity of the duodenum or of the pancreas with the intestine.

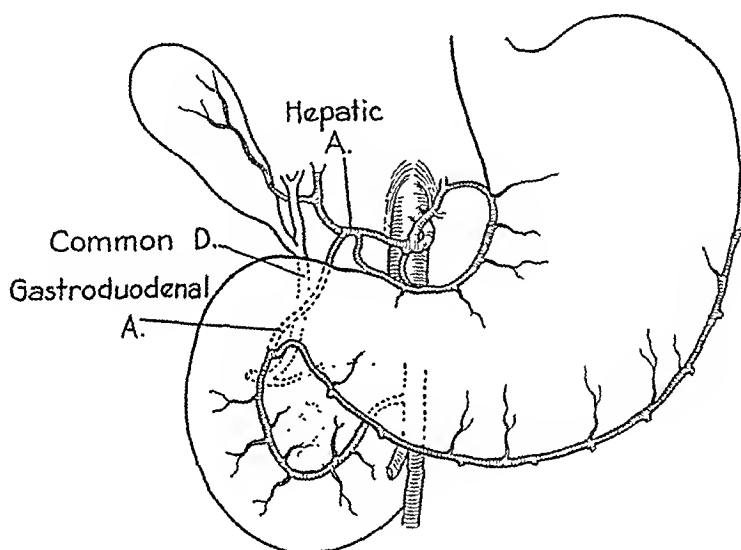


FIG. 1.—Normal anatomy of biliary tract and vessels in the operative field.

2—That the operation be a two stage one with definite steps in each stage and with the following technic:

(a) Spinal pantocaine anesthesia.

(b) A right rectus or epigastric midline incision for the first stage, with the following steps:

(1) Posterior gastro-enterostomy.

(2) Ligation and section of the common duct below the cystic duct after determining the patency of the cystic duct, and leaving a long black silk ligature as an indicator on the lower stump of the sectioned common duct. The great difficulty in finding the unsectioned duct in our first case and in dividing it at a sufficiently high level impelled us to divide the duct at the first procedure and to mark it with a clear signal.

(3) A cholecystgastrostomy to the anterior surface of the stomach well away from the pylorus, using an anastomotic opening at least 2 cm. in diameter, in order to avoid subsequent stenosis and cholangitis.

3—Three to four weeks after the first stage the second procedure is carried

CARCINOMA OF AMPULLA OF VATER

out through a transverse incision above the umbilicus through both recti, if necessary, under spinal anesthesia. The steps in this second stage are as follows:

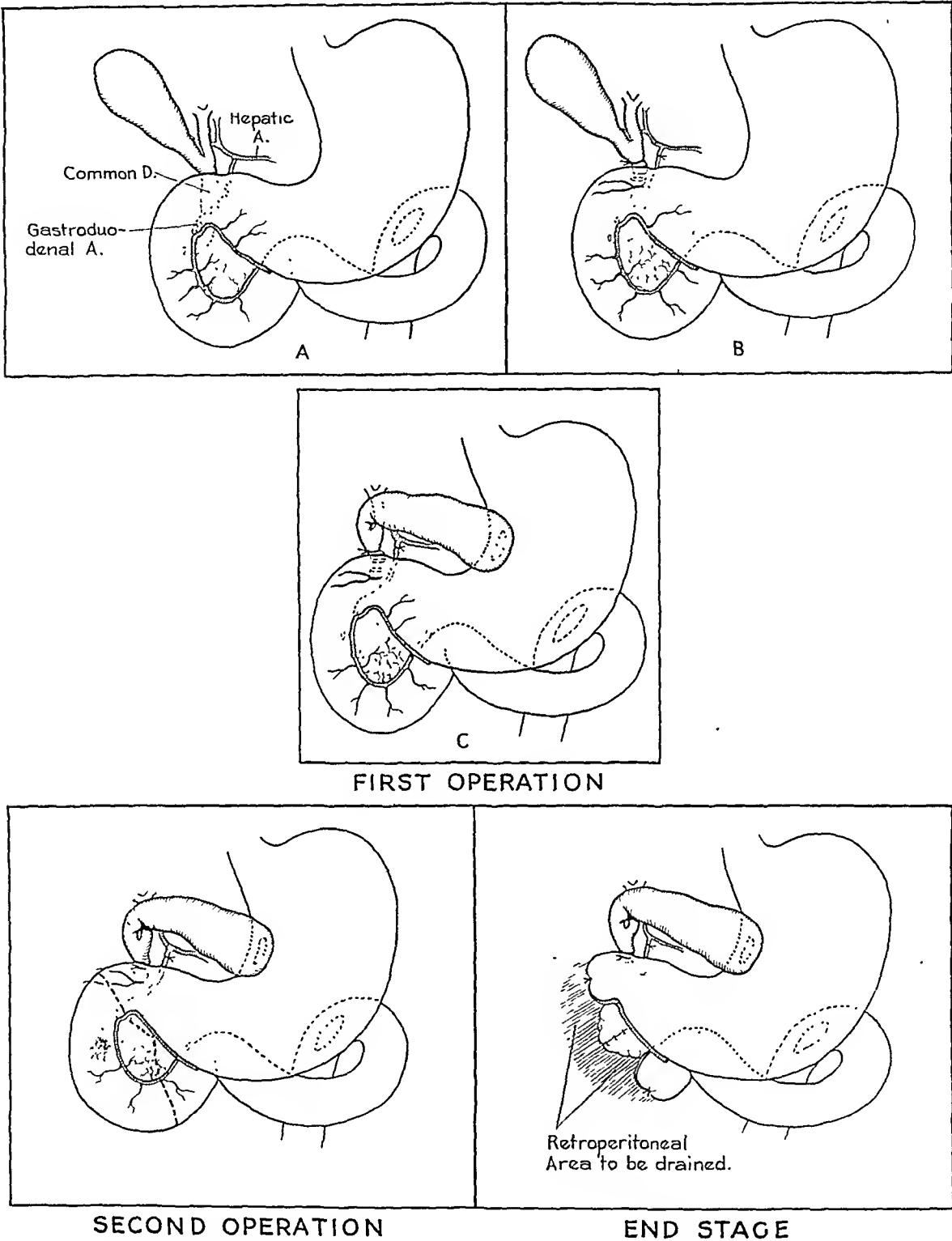


FIG. 2.—Consecutive steps in the two stages of the operation.

- (a) Ligation of the pancreaticoduodenal and gastroduodenal arteries.
- (b) Resection of the descending portion of the duodenum with inversion of the upper and lower ends, and a V-shaped excision of the head of the pan-

creas wide of the growth together with the common duct, using the silk ligatures as a guide to the lower cut end of the duct.

(c) A ligation of the cut end of the duct of Wirsung—and the duct of Santorini, if present—and the suturing of the two cut surfaces with interrupted fine silk.

(d) Drainage of the bed of the resected duodenum with cigarette drain.

4—Silk technic for both the first and second stages of the operation, using the finest silk for all but the large arteries.

We report the three cases subjected to radical removal of carcinoma of the papilla of Vater. The literature on the operative treatment of carcinoma of the peri-ampullar region of the duodenum was completely summarized by Cohen and Colp⁴ in 1927. Shorter reviews have also been published by Fulde⁵ and Lauwers.⁶ Cohen and Colp were able to collect 59 cases treated by radical operation—one was not excised, but had radium applied locally. Of these, 24 died following operation; 13 died of recurrence; one died nine months later of cholangitis; and 21 or 35.6 per cent survived the operation and lived for varying periods, Kelly's case being well after eight and a half years, and Koerte's case for 22 years.

TABLE I
Cases Reported from 1927 to 1935

Year	Author	No. Cases	Age	Sex	Diagnosis	Operation	Result
1925	Homans	1	?	?	Carcinoma of ampulla	Transduodenal removal with cautery	Well after "several years"
1927	Fulde	1	46	M.	Carcinoma of ampulla	Transduodenal removal with reimplantation of common and pancreatic ducts	Well after 2 yrs.
1927	Clar (Pamperl)	1	?	?	Carcinoma of ampulla	Transduodenal removal with reimplantation of common and pancreatic ducts	Well at end of 5 yrs.
1928	Busch	1	53	M.	Carcinoma of ampulla	Transduodenal removal with reimplantation of common and pancreatic ducts	Well after 1 yr.
1928	Del Valle§	1	42	M.	Carcinoma of ampulla	Transduodenal removal, choledochotomy, cholecystectomy and appendectomy	Operative recovery
1929	Klinkert (7)	2	53	M.	Carcinoma of ampulla	1st stage: Cholecystjejunostomy. 2nd stage: Transduodenal removal and gastro-enterostomy	Died after 3 mos. with liver metastases
	Pollet's case (8)#		?	?	Carcinoma of ampulla	1st stage: Cholecystjejunostomy. 2nd stage: Transduodenal removal with reimplantation of common and pancreatic ducts	Operative recovery
1930	Bengolea	1	37	F.	Carcinoma of ampulla	Excision through choledochotomy opening and drainage of common duct	Reoperation 3 mos. later for jaundice. Metastasis in local lymph node
1932	Walters	1	50	M.	Carcinoma of ampulla	Transduodenal removal of papilla and reimplantation of common duct into duodenum	Well after 2 mos.
1932	Judd*	1	38	M.	Carcinoma of ampulla	Transduodenal removal 6 wks. after cholecystostomy and choledochotomy	Recurrence. Lived over 2½ yrs.
1932	Pemberton*	1	44	M.	Carcinoma of ampulla	Transduodenal removal, choledochoduodenostomy, and reimplantation of pancreatic duct into duodenum	Recurrence. Lived 2½ yrs.

CARCINOMA OF AMPULLA OF VATER

TABLE I (Continued)

Year	Author	No. Cases	Age	Sex	Diagnosis	Operation	Result
1933	Potter	1	57	F.	Carcinoma of ampulla	Transduodenal removal with reimplantation of common and pancreatic ducts into duodenum	Operative recovery.
1933	Cabot†	1	35	M.	Carcinoma of lower common duct	Resection of lower common duct with choledochoduodenostomy	Well for 8 yrs.
1933	Coller†	1	64	M.	Carcinoma of lower common duct	Resection of lower end of common duct	Postoperative death
1933	Lauwers	2	51	M.	Carcinoma of ampulla	Transduodenal removal with cauterization. Cholecystjejunostomy	Well after 3 yrs. and 10 mos.
			52	M.	Carcinoma of ampulla	Transduodenal removal with cauterization. Cholecystjejunostomy	Well after 9 mos.
1934	Santero	2	50	M.	Carcinoma of ampulla	Transduodenal removal	Both recurred soon
			72	F.	Carcinoma of ampulla	Transduodenal removal	
1935	Whipple	1	60	F.	Carcinoma of ampulla	1st stage: Choledochoduodenostomy and cholecystostomy. 2nd stage: Resection of ampulla and adjacent pancreas with pancreatoduodenostomy	Postoperative death from duodenal leakage
1935	Parsons	1	53	M.	Carcinoma of ampulla	1st stage: Cholecystgastrostomy. 2nd stage: Resection of duodenum and head of pancreas with closure of pancreatic stump. End-to-end suture of duodenum. 3rd op. gastro-enterostomy	Died in 8 mos. of cholangitis
1935	Whipple	1	49	M.	Carcinoma of ampulla	1st stage: Gastro-enterostomy, ligation and division of common duct, and cholecyst-gastrostomy. 2nd stage: Resection of duodenum and head of pancreas with closure of pancreatic stump	Well after 3 mos.
1935	Janes‡	1	?	M.	Carcinoma of ampulla	1st stage: Cholecystgastrostomy. 2nd stage: (3 wks. later) Resection of duodenum and adjacent pancreas, closure of pancreatic stump, ligation of common duct, and gastro-enterostomy	Postoperative death from pneumonia.

* Reported by Walters.

† Reported by Potter.

‡ Personal communication.

Schofield's case not included—treated by radium (13).

§ Reported by Llambias, *et al.*

‡ Reported by Klinkert.

TABLE II
All Reported Cases

Operation	No. Cases	One Stage	Died	Lived	Two Stage	Died	Lived
Transduodenal excision..	65	60	22	38	5	0	5
Resection of duodenum..	6	3	1	2	3	1	2
Retroduodenal excision..	3	3	1	2			
Resection of common duct	3	2	1	1	1	0	1
Resection of duodenum and pancreas with closure of pancreatic stump	3				3	1	2
Total.....	80	68	26 (38%)	43	12	2 (16.6%)	10

The reported cases since 1927 are listed in Table I, giving a total of 22 cases including the three here presented. In this group there were three postoperative deaths, and six are known to have had recurrence of the tumor. Thus out of a total of 80 cases, 28 or 35 per cent died an operative death, and 20 others, or 24.6 per cent, are known to have had recurrence. It is probable that many of the remaining 34 cases also died from cancer, since only a short follow up is available in the majority.

TABLE III
Presbyterian Hospital Cases with Autopsy

Case	Age	Sex	Autopsy Diagnosis	Metastases
9747	82	M.	Carcinoma of ampullar region (probably common duct origin).....	0
9850	65	M.	Carcinoma of terminal common duct with invasion of pancreas and metastases to liver.....	+
10489	65	F.	Carcinoma of ampulla (probably common duct).....	0
10111	55	M.	Carcinoma of terminal common duct with extension to pancreas and microscopic metastasis to a local lymph node.....	+
10699	67	M.	Carcinoma of terminal common duct.....	0
10839	56	F.	Carcinoma of peri-ampullar region of duodenum....	0
11011	60	M.	Carcinoma of peri-ampullar region of duodenum....	0
Total—M. = 5.				
F. = 2.				
With metastases = 2.				
Without metastases = 5.				

CASE REPORTS

CASE I.—W. S. Unit History 70844. C. C.—Jaundice of ten weeks' duration. *Family History*.—Irrelevant. *Past History*.—Partial thyroidectomy for hyperthyroidism four years before. Patient had suffered from symptoms of epigastric fullness for seven years and a duodenal diverticulum had been demonstrated by roentgenogram.

Present Illness.—For ten weeks patient has noted progressive painless jaundice with anorexia, dark urine, occasional abdominal cramps and loss of ten pounds in weight.

Physical Examination.—A white female 60 years of age, deeply jaundiced. Temperature 101.4°; pulse 75; respirations, 20; blood pressure 130/85. The liver is palpable 4 cm. below the right costal margin and beneath this an indefinite mass which seems to be gallbladder. The physical examination is essentially negative otherwise.

Laboratory Data: Hemoglobin, 77 per cent; red blood cells, 3,670,000; white blood cells, 8,350,000 (64 per cent neutrophils). Sedimentation rate, 70 Mm. in one hour. Blood amylase, 13.4. Duodenal drainage—bile stained fluid obtained, showing no cholesterol crystals and containing pancreatic ferments. Roentgenogram of the abdomen showed no calcified shadows. Urine, bile stained. Serum bilirubin, 6.8 mg. per 100 cc.

First Operation.—March 16, 1934. Choledochoduodenostomy and cholecystostomy. *Pathology*.—The gallbladder was distended and a small mass in the region of the ampulla of Vater could be felt. *Procedure*.—As described. *Course*.—The patient did fairly well following operation, and the jaundice cleared. The drainage tract closed in the third week.

Second Operation.—May 7, 1934. Resection of ampulla of Vater and pancreatico-enterostomy. Resection of the duodenal wall in the ampullar region with part of the

adjacent pancreas and suture of pancreas into the duodenal wall defect. The distal common duct was not well visualized. Course.—The patient went rapidly down hill and died about 30 hours after operation.

Pathologic Report.—Adenocarcinoma of the ampulla of Vater, apparently arising from the duodenal mucosa. The ampullar opening was completely closed off. Autopsy.—Showed acute localized peritonitis with fat necrosis in the region of resection, with leakage from the lower end of the common duct. There were no metastases.

CASE II.—E. W. Unit history 422730. C. C.—Severe itching of skin and painless jaundice, of two months' duration. *Family History.*—Grandfather died of carcinoma of the stomach. *Past History.*—Usual childhood diseases. Malaria many years ago. "Blood poisoning" nine years ago following infected left elbow. Gonorrhoea ten years ago with treatment.

Present Illness.—First admission of a 53 year old Nova Scotian boat builder for itching and jaundice, two months' duration. Nausea, no vomiting. Appetite very poor,



FIG. 3.—Case I.—Low power photomicrograph showing carcinoma of ampulla of Vater with stenosis of the lumen.

unable to eat fatty foods. Clay colored stools. Loss of 20 pounds in the past three months.

Physical Examination.—Temperature, 100.2°; pulse, 98; respirations, 18; blood pressure, 104/60. Poorly developed and emaciated old man, who is intensely jaundiced. Eyes—sclerae jaundiced. Lungs clear. Abdomen—distended liver edge two fingers down. No spasm or tenderness.

Laboratory Data.—Blood amylase, 5.8. Serum bilirubin, 10.7 mg. per 100 cc. Wassermann, negative.

First Operation.—Cholecystgastrostomy. July 18, 1934. Pathology.—A moderate number of adhesions were present in the right upper quadrant. The gallbladder was thickened, pale, markedly distended, containing 300 cc. of café au lait bile. No stones were made out in the gallbladder or common duct. The head of the pancreas presented a firm enlargement, somewhat nodular in shape, firm in consistency, lying on the deep surface of the organ. It was too deep to warrant the removal of a specimen. No metastases were seen in the liver. Procedure.—15 cm. right upper rectus incision. Silk technic.

Procedure as described. Course.—Uneventful. Sutures out seventh day, retention sutures out twelfth day. Wound healed by primary union. Up fifteenth day. Discharged August 14, feeling very well, to return in about a week for second operation.

Second Operation.—Partial pancreatectomy. Partial duodenectomy. Duodenoduodenostomy. August 21, 1934. Pathology.—The stomach was adherent to the under surface of the liver, so that the cholecystgastrostomy could not be seen. The common duct was enlarged, being a full centimeter in diameter. There was a hard mass at the region of the papilla of Vater which apparently also involved the neighboring pancreas. At least, this area of the pancreas was thickened. There was a slight amount of free fluid in the upper peritoneal cavity. Procedure.—Transverse incision across upper abdomen. Procedure as described. Patient was transfused at the end of the operation.

Pathologic Report.—Diagnosis: carcinoma of papilla of Vater.

Course.—Persistent vomiting after this operation, approximately 2,000 cc. a day, with nothing by mouth, was a serious complication. An obstruction at the site of the du-

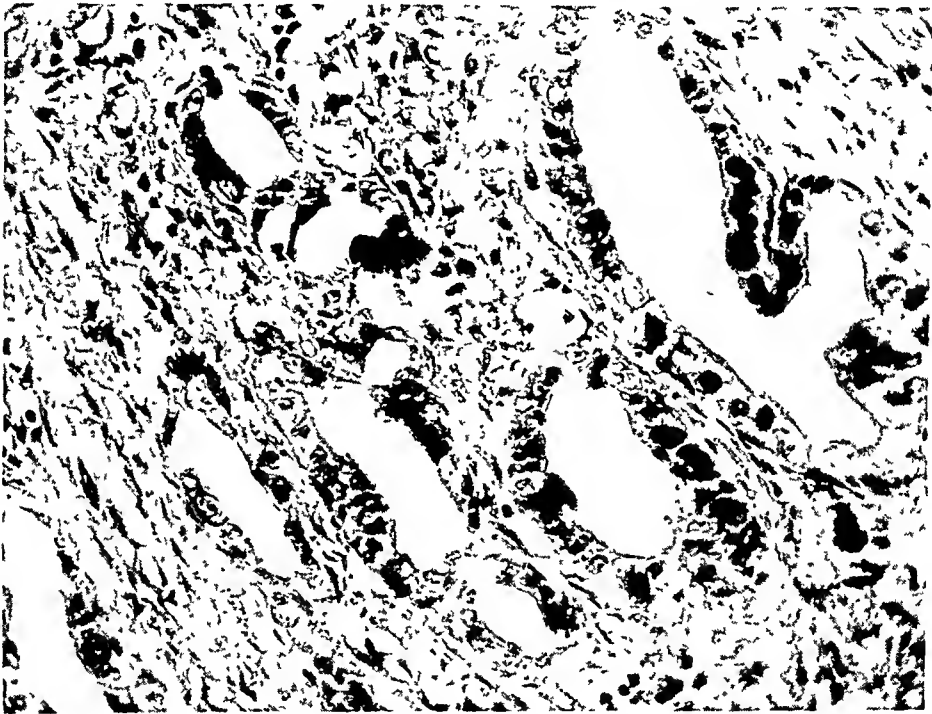


FIG. 4.—Case I.—Higher magnification showing the fairly well differentiated glands in the tumor.

odenoduodenostomy was thought to be the cause of this, so one week later a third operation was done.

Third Operation.—Anterior gastro-enterostomy. Entero-enterostomy. August 29, 1935. Pathology.—There was no free fluid. No evidence of fat necrosis. Area of previous operation not inspected. Procedure.—Fifteen cm. left upper rectus incision. Procedure as described. Silk technic. Course.—Patient had a very good recovery considering the severity of his previous operations. All wounds healed well. No leakage or drainage of pancreatic ferments. Following the pancreatectomy his blood amylase rose to 72 and then gradually fell to around 30. Blood sugar has been normal. Studies of his protein and fat digestion since operation show about an 80 per cent protein digestion and about 50 per cent fat.

Patient continued well until about March 4, when he began to have abdominal discomfort associated with head cold. Jaundice, light colored stools, dark urine, vomiting, for the past week. No itching. Chills and fever. He was readmitted March 25, 1935.

CARCINOMA OF AMPULLA OF VATER

Physical Examination.—Skin dry and warm. Eyes—sclerae jaundiced. Lungs clear. Heart—sounds of good quality, no murmurs. Abdomen—incisional scars with herniation in central portion of epigastrium. Liver is felt 3 to 4 cm. below costal margin and is diffusely tender abdominally and on rib percussion. Abdomen soft and non-tender elsewhere, but moderately distended. Temperature, 104.6°; pulse, 100; respirations, 24; blood pressure, 140/85.

Laboratory Data.—Blood amylase, 11.4. Serum bilirubin, 8.2 mg. per 100 cc. Blood sugar, 1.30 Gm/L. Blood CO₂, 49cc. per cent. Blood calcium, 7.4 mg. per 100 cc. Blood phosphorus, 1.7. Blood culture positive for *B. lactis aerogenes*. Course.—Patient ran a spiking temperature, 100°–104°, and gradually became weaker. He succumbed on April 18, 1935, three and one-half weeks after admission and approximately eight months after the radical operation.

Autopsy.—The peritoneal cavity contained about 500 cc. of yellowish fluid. There were firm adhesions between the stomach and the under surface of the liver. The spleen



FIG. 5.—Case II.—Low magnification indicating complete replacement of lumen of ampulla of Vater by tumor tissue

was enlarged, weighing 320 Gm., and was of uniform red color. The liver weighed approximately 3,100 Gm, and contained numerous yellowish nodules varying in size from a few millimeters to 1½ cm. across. On section these contained purulent exudate. The hepatic ducts were dilated and the gallbladder also, the latter containing numerous soft yellowish stones and some sand-like material. The common duct was dilated, and at its lower end where it had been ligated there was a small amount of firm whitish tissue which microscopically showed carcinoma. There were no other areas of carcinoma found. The cholecystgastrostomy opening was contracted so that it admitted only a small probe. The pancreas was 12 cm in length, with grayish-yellow lobules and abscess cavities scattered throughout the parenchyma. There were no connections between the pancreas and the intestinal tract. The pancreatic duct was moderately dilated. The remainder of the examination, including the chest cavity and the thyroid, showed nothing except multiple abscesses in the lungs and kidneys, the result of the septicemia. Microscopically the liver showed evidences of the marked infection with many abscesses. The portal areas showed some increase of connective tissue with inflammatory cells. There

was no fatty degeneration noted. The pancreas showed, in addition to the multiple abscesses, moderate fibrosis and atrophy of the acinar tissue.

It was the pathologist's opinion that the sequence leading to death was stenosis of the cholecystgastrostomy opening, with bile stasis, infection, septicemia and death.

CASE III.—M. J. Unit History 440080. C. C.—Itching and jaundice, and clay colored stools of two and one-half months' duration. *Family History*.—Negative. *Past History*.—Negative except for malaria 18 years ago, Gonorrhoea 20 years ago. Gas and belching p.c. for past 20 years.

Present Illness.—For past two and one-half months patient has had epigastric pain, colicky, and nausea and anorexia. No vomiting. This was followed two weeks later

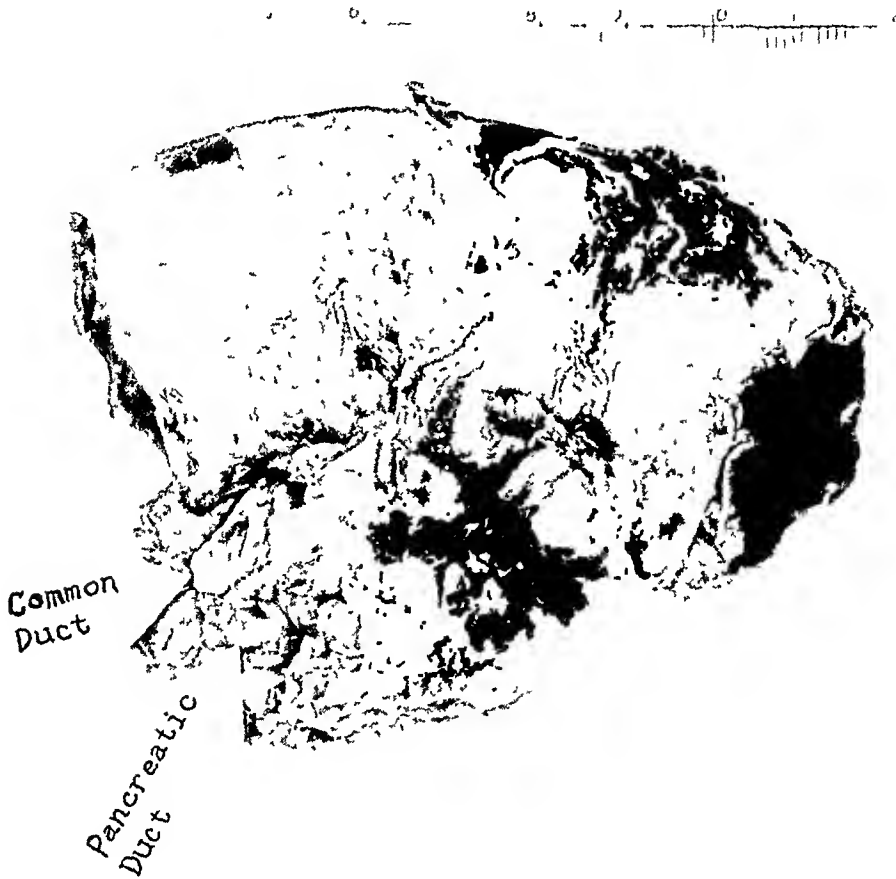


FIG. 6.—Case III.—Posterior view of gross specimen consisting of duodenum and head of pancreas. Note dilated common and pancreatic ducts

by jaundice, clay colored stools and dark urine. No pain since the first attack, which lasted one-half hour. Had previously had belching and distress after meals for 20 years. Loss of 18 pounds in three months.

Physical Examination.—A well developed colored man of 49 with a greenish tinge to his skin, and markedly icteric sclerae. Heart not enlarged, sounds regular, good quality. Lungs negative. Abdomen—liver edge is felt 6 cm. below costal margin. No signs of fluid. Examination otherwise negative. Temperature, 98.8°; pulse, 70; respirations, 20; blood pressure, 110/70.

Laboratory Data.—Hemoglobin, 76; red blood cells, 4,000,000; white blood cells, 7,400; polymorphonuclears, 66. Bleeding and clotting time, normal. Stool negative for

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bile or blood. Serum bilirubin, 10.9. Wassermann—Cholesterol 3+, Alcohol, negative. Repeat Wassermann negative. Duodenal drainage—no bile obtained. Sedimentation rate 65, defibrinated 3, Takata slightly positive. Urine—bile positive.

Patient was discharged to decide on operation and returned two days later, January 24, 1935. Blood N.P.N.—20 Gm./L Serum bilirubin, 8.0 mg. per 100 cc. Roentgenogram of abdomen negative for stones.

First Operation.—January 25, 1935. First stage procedure for excision of duodenum and head of pancreas for carcinoma, consisting of gastro-enterostomy, cholecystgastrostomy, and ligation of the common duct below the cystic duct.

Pathology.—The findings in this patient promised unusually well for removal of what was considered to be a carcinoma of the papilla. The common duct obstruction was thought to be due to a small tumor mass about two centimeter in diameter situated in the region of the papilla. The common duct was markedly dilated, as was the gallbladder, but no stones were made out in either the gallbladder or common duct. There was an anomaly of the cystic duct which complicated the procedure somewhat, inasmuch as ligation of the common duct had to be carried out at a lower level than was desired because of the long cystic duct emptying into the common duct in the retroduodenal portion on the common duct. There were no enlarged nodes made out. No masses palpable in the liver. The liver was somewhat enlarged due to the common duct obstruction.

Procedure.—A reversed L-shaped incision was made in the right upper quadrant. Procedure as described. Silk technic. Course.—Little or no reaction following operation. Jaundice subsided. In four days had bile in stools and bile disappeared from urine a few days later. Serum bilirubin dropped slowly from eight milligrams before operation, and was still showing a trace on the twenty-fifth day. On the thirteenth day resection was done.

Second Operation.—February 7, 1935. Resection of duodenum and head of pancreas. Spinal anesthesia. Procedure.—Transverse incision above umbilicus. Adhesions were rather numerous, but duodenum could be mobilized and turned forward to the left. After this the lower end of the common duct was isolated with some difficulty and the duodenum was resected, the point of section being just distal to the pylorus above and proximal to the superior mesenteric vessels below. A wedge-shaped portion of the head of the pancreas was then removed, so that the specimen included the ampulla of Vater and the tumor. The duodenal ends were then inverted and the pancreatic stump closed with interrupted silk sutures.

Course.—Little reaction following second operation, but a serous discharge on the third day which on analysis showed pancreatic ferment. Blood amylase was 40 on the day of operation and 44 the following day—remained below 20 after this. Fasting blood sugar rose to 1.28 on the second day, and was under 100 after this. The discharge persisted in moderate amounts up to the eighth day, following which there was a small amount, apparently from the subcutaneous tissues at the site of the drain. Up on the twelfth. Discharged on eighteenth day with a small draining wound.

Pathologic Report.—*Gross.*—The specimen consists of a portion of the head of the pancreas, the duodenum, and the common bile duct and pancreatic duct, removed in a second stage operation for carcinoma of the papilla of Vater. In the fixed stage the duodenum measures nine centimeters long on its convex surface. The serosal coat is rough and somewhat shrunken, owing to having been torn by retractors. A mass can be palpated through the wall in the region of the papilla.

On opening the duodenum there is a small ulceration about 6 Mm. in diameter, which is irregular in shape and occupies the site of the opening of the papilla into the lumen of the duodenum. No opening, however, can be made out. The tissue beneath this is indurated and fixed to the wall.

The pancreatic tissue removed with the specimen measures 5 by 3 by 2.5 cm. and is attached to the concave surface of the duodenum in its upper portion. The common bile duct and the pancreatic duct can be seen coursing through the upper portion of the pan-

creatic tissue. The common bile duct, where it has been cut through, measures about 7 Mm. in diameter. The pancreatic duct measures 4 Mm. in diameter. A probe inserted into each of these in the fresh specimen passed to the papilla but not through any opening into the duodenum.

On section the two ducts are seen to course side by side towards the region of the papilla, and just below the papilla there is a firm, grayish-white, ovoid mass measuring 1.3 by .8 by 1 cm. which appears to have not only involved the papilla of Vater but has completely destroyed the lower end of the pancreatic duct and bulges in toward the lumen of the lower end of the common duct, invading the wall of both of these and blocking the opening completely.

Situated on the upper anterior inner wall of the duodenum, 6 Mm. from the upper line of resection, is a small papillary shaped nodule measuring 3 Mm. in diameter and

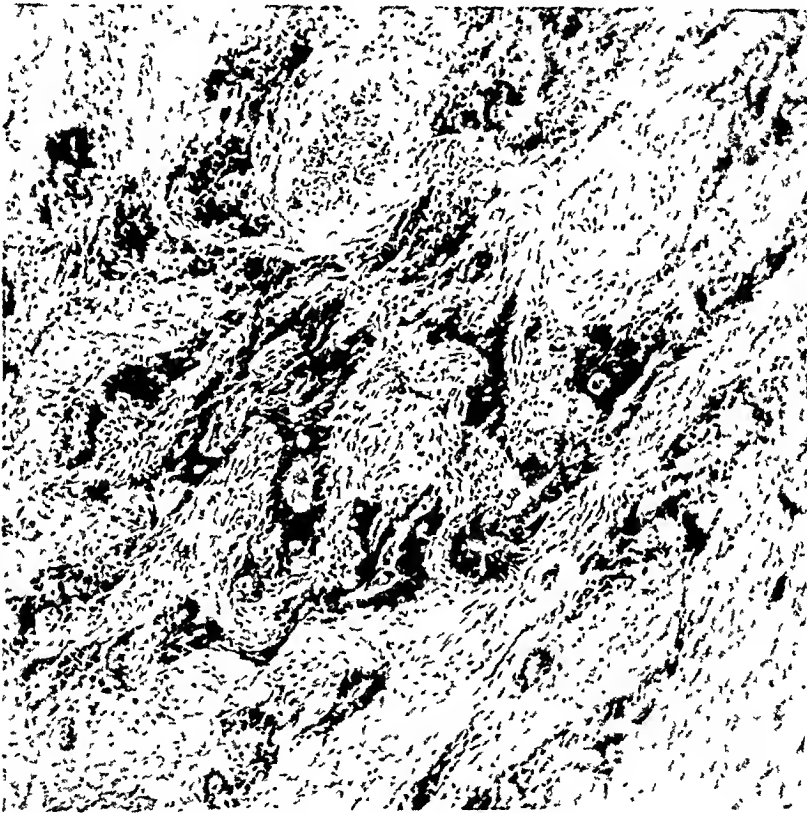


FIG. 7.—Higher magnification of tumor from Case III, showing the carcinoma cells.

raised above the mucosal surface 1 Mm. This has two tiny openings or depressions within it. A section of this, however, reveals no duct-like structure under it or any connection with the pancreas which might suggest an accessory pancreatic duct.

On the posterior aspect of the duodenum and pancreas six lymph nodes were found, the largest measuring 8 by 5 by 4 Mm. All of these are soft except one which is situated immediately behind the tumor and firmly adherent to it, and is harder and filled with white tissue, and appears to have been involved by direct extension.

Microscopic.—A section has been taken longitudinally through the common duct, pancreatic duct, ampulla, and includes a portion of the pancreas. The common duct histologically appears patent, but is obstructed by the tumor mass which involves the entire lower end of the pancreatic duct and adjacent duodenum where it joins the lower aspect of the papilla of Vater. The tumor is a carcinoma made up of irregular, infiltrating glands and strands of small hyperchromatic epithelial cells which show mitoses on an average of 1 per high power field. These cells secrete large amounts of mucin in

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some areas. Both sides of the lower end of the common duct at the ampulla are involved with the tumor tissue. The surface of the tumor at the ampulla is ulcerated and covered with inflammatory cell debris. The tumor does not extend upwards along either the common or pancreatic ducts. No direct extension can be seen through the duodenal wall into the pancreas.

A section through the small nodule at the upper line of resection of the duodenum shows this to be composed of an adenomatous mass of duodenal mucous glands which are perfectly regular in shape and only show a small amount of epithelial hyperplasia. A few deep crypts can be seen presenting on the lumen side, but no real ducts, which might be considered an accessory pancreatic duct.

Sections of all the lymph nodes show one to be definitely involved with a small metastasis. In addition, the firm white node adherent to the deep surface of the tumor shows carcinoma bordering it, but not actually invading, and extending completely through the adjacent issue. This would indicate that some tumor was left behind at the time of operation. The prognosis, owing to this last finding and owing to the metastasis, must be considered unfavorable. *Diagnosis.*—Carcinoma of ampulla of Vater with metastases to retroperitoneal lymph nodes.

Second Admission, March 25, 1935. Discharged April 13, 1935. The patient was well until March 25, 1935, about two months after operation, when he was seized with sudden severe epigastric pain which became steadily worse, and was accompanied by a bile stained vomiting. He was readmitted, at which time his temperature was normal. He had upper abdominal spasm and tenderness. White blood cells, 21,900; polymorphonuclears, 92 per cent; blood amylase, 72. Examination of the stools at this admission for fat absorption showed that he was utilizing 88 to 90 per cent of his fat intake. Blood calcium and phosphorus were normal.

Third Operation.—March 25, 1935. Exploratory celiotomy. The patient was explored under spinal anesthesia. In the region of the right upper quadrant there was a small pocket containing 20 to 30 cc. of yellowish fluid, the culture of which showed *B. coli* and non-hemolytic streptococcus. The tissues in this area were very edematous, and although no fat necrosis was present, it was felt that the patient had a mild acute pancreatitis. This area was drained, and the patient made an uneventful recovery.

Course.—The fistula drained what apparently was pancreatic juice (since it contained all the ferments), for about two weeks, and then closed. The patient was discharged in good condition April 13, and has remained well since that time.

DISCUSSION

The operation proposed in this paper has certain advantages over those previously described.

(1) It carries out the principle of cancer surgery in excising, *en bloc*, tissues wide of the growth. In this particular condition this principle is applicable because extension of the growth from the papilla has been found to be either into the neighboring pancreas or up along the lining of the common duct.

(2) The hazard of surgery is reduced by a two stage procedure, insuring the relief of jaundice and improvement of nutrition by the first stage and excising the lesion radically when the risk to the patient is minimized. In our first case of radical removal, duodenal obstruction appeared later because of the drag set up against the superior mesenteric vessels. We therefore have inserted a gastro-enterostomy as part of the first stage.

There are certain theoretical objections to the removal of a large part of the duodenum and permanent obstruction of the pancreatic ducts.

Hershey and Soskin⁹ and Berg and Zucker¹⁰ noted fatty degeneration of the liver in animals with ligation of pancreatic ducts, and with total pancreatectomy.

Sweet³ described a peculiar translucence and atrophy of the spleen and thyroid in the dog after obstruction of the external pancreatic secretion. In our patient coming to autopsy, because of a cholangitis eight months after the radical operation, none of the above changes was noted in liver, thyroid, or spleen.

The objection to this procedure on the basis of disturbed fat digestion due to lack of pancreatic ferments was considered, but much to our surprise the utilization of fat in both of our patients several weeks after the radical procedure was remarkably good, 85 to 90 per cent of the fat intake was absorbed, as shown by stool examinations. Furthermore, both patients gained and maintained their normal weight three and seven months after operation.

That there may be a compensatory secretion of fat splitting ferment in the upper intestine is suggested, but requires further experimental study before any positive statement can be made.

A certain amount of atrophy of the acinar tissue of the pancreas has already taken place in these patients before they come to operation, due to the obstruction of the pancreatic duct by the neoplasm. This probably accounts for the small amount of leakage of pancreatic juice after this operation.

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DISCUSSION.—DR. DAMON A. B. PFEIFFER (Philadelphia, Pa.).—I have little in the way of personal experience to add. It is very fitting, however, that this Society should recognize the importance of this contribution because it is quite apparent that a new and brilliant chapter is being added to the surgery of this condition.

None of us is too young to be aware of the timidity with which surgeons in general have approached any radical interference on the pancreas. It is true that in 1884 Billroth, that great pioneer and innovator, reported complete removal of the pancreas with success from an immediate operative standpoint, but his lead found few followers. A few years later, Mikulicz, then possessing the greatest authority in the surgical world, pointed out the enormous increase in mortality entailed in operations or removal of the stomach when the pancreas itself was in any way included.

Gradually, however, as a result of isolated experiences, it became apparent

that some surgery, at least, could be done upon the pancreas, that limited resections could be made safely, and Finney, in this country, was one of the first to draw our attention to the feasibility of such procedures. He reported before this Association in 1910 a case of resection of the body of the pancreas for benign tumor. The two divided ends were reunited and the result was entirely satisfactory.

Following this, sporadic cases of limited resection for various indications appeared in the literature and surgeons in general began to lose their fear of operative procedures on this organ.

The dangers of interfering with the head, however, deterred almost everybody from attempting radical intervention in that location. It is true Desjardins, in 1897, devised a very ingenious operation that was satisfactory mechanically for the removal of the head of the pancreas. It involved three separate anastomoses, one to restore continuity of the gastro-intestinal tract, one to reintroduce the bile into the intestine, and another to preserve the external secretion of the pancreas, which was at that time thought to be essential to life.

Naturally, such procedures are hardly feasible in cases as met clinically and Finney, in his paper, sounded a very pessimistic note as to the possibility of ever being able to carry it out. However, this new contribution shows that by proper combination of procedures it is entirely feasible to resect the ampulla, which means resection of the head of the pancreas. By a little extension of our imagination now we can see ourselves removing early carcinomata from the head of the pancreas if we are fortunate enough to get and recognize them in time.

The difficulties of recognition of this condition in the early operable stage are great. The success of this procedure depends apparently upon recognition of two things, first of all, the importance of separating the operation into two stages. That important military maxim of "divide and conquer" has been applied successfully now in many situations and here apparently it gets a new application. It necessitates, however, an absolute diagram before embarking upon the plan.

The second important thing to appreciate is that the external secretion of the pancreas is not essential to digestion and preservation of life. We might have deduced this from experiment and proved it to be true. As a matter of fact, I think pathologists were aware of it before clinicians. I recall in my course of pathology at Johns Hopkins, that Opie had somewhere obtained a specimen of a pancreas at the autopsy table, which consisted of nothing more than islands of Langerhans imbedded in fibrous tissue. All the glandular elements of external secretion had disappeared, but the patient had lived for a considerable time. It remained for later work to show it is possible to avail ourselves of this fact clinically.

The difficulty of diagnosis to which I refer may be illustrated by a case which I had only recently, a man whose history and condition were in every way typical of stone in the common duct. At operation he had a small thick gallbladder containing stones and a hugely dilated common duct. I opened his common duct and found no stone, no sand, no indication of any foreign material in the duct.

With the greatest difficulty, I finally succeeded in introducing a probe into the duodenum, dilated the opening and felt I was dealing with stricture of the papilla of Vater, put in a T tube, and stopped. He made a good recovery and bile at first passed into his intestine. After removal of the tube, however, his internal damage persisted and bile finally ceased to flow into his duodenum. It was apparent he had complete obstruction in his common duct. I felt pos-

sibly I had overlooked a stone. I again explored his common duct, which at that time was big enough so I could introduce my finger into the distal portion of the duct, and came to a dead end. I could feel it perfectly well. There was no suggestion of tumor formation. There was no stone, but simply a dead end at the intestinal extremity. I made a choledochoduodenostomy and the patient promptly got well and has remained so.

I had never met with a similar case, but Ellsworth Eliot referred me to a report by Herferth some years before in which he had found at autopsy what he called prolapse and intussusception of the common duct. It was an entirely new entity to me, but it seems to fit this case. In this condition the end of the common duct had bulged into the duodenum, reversed itself and mechanically completed the obstruction of the strictured papilla.

My admiration for the surgeons who carried out this very successful operation is not only for the ingenious, brilliant operative procedure which they have devised, but also for their boldness in making this a positive diagnosis in this early stage.

DR. EVARTS A. GRAHAM (St. Louis, Mo.).—I wish to compliment very highly Doctors Whipple, Parsons and Mullins for their brilliant work. It is another example of the step-like progress which has to be made before a final goal is reached.

I wish to discuss for a moment the question of the importance of the pancreatic juice in digestion.

There was no evidence so far as I know that in a rapidly growing young subject it is possible to carry on a normal development without much pancreatic juice until suddenly an emergency which confronted me approximately two years ago seems to have established the fact. I operated on a baby that was less than two years of age because of intractible hypoglycemia which retarded it greatly, both mentally and physically. We hoped to find a pancreatic adenoma at operation, but the pancreas looked perfectly normal. In view of the previous partial resections of the pancreas which had been made by Judd and Finney among others, in the absence of finding a definite adenoma, I decided that it might be worth while to make as nearly a total resection of the pancreas in this youngster as was possible, without jeopardizing the common bile duct.

The procedure was carried out successfully; the case was reported in September, 1934. One month ago I had a letter from this little girl's mother, which stated that the child had developed in a perfect manner physically, and that there seemed to have been no difficulty, whatever, with her digestion. At operation I performed a subtotal removal of the pancreas, leaving only a little strip of tissue along the common bile duct to protect it.

The operation, therefore, described by Doctors Whipple, Parsons, and Mullins, I feel is based on what seems to me to be thoroughly sound physiologic evidence of the fact that, so far as the secretions of the pancreas are concerned, it is a perfectly safe procedure to carry this operation out, especially in view of the fact that if a rapidly growing child can apparently get along perfectly well without the external secretion of the pancreas, certainly an adult ought to be able to do so. There is another point, however, which deserves some comment. What assurance have we that a patient can go along indefinitely with a cholecystogastrostomy or a cholecystoduodenostomy without developing a severe infection of the liver? The evidence with which I am familiar indicates that almost invariably the patient succumbs from multiple abscesses in the liver if the anastomosis remains open. It might be possible, however, to devise an anastomosis which would prevent the ascend-

ing infection, in a manner perhaps analogous to the Coffey operation of transplantation of a ureter.

DR. WILLIAM PARSONS (New York).—Dr. Eliason is about to publish an article in which he discusses the question of cholecystogastrostomy. In our patient who died, we feel beyond a doubt his septicemia was the same type that so many cholecystogastrostomies will show later on.

Doctor Eliason quotes Bernard in an article showing that about 25 per cent of a rather large series of cholecystogastrostomies, performed for a variety of conditions, were followed by cholangitis. In this particular case, although we tried to make a large opening, the gallbladder was so enormous I think we did not estimate the degree to which it was going to contract later on. At postmortem the cholecystogastrostomy opening admitted only a probe and it was quite obvious that this was the cause of the bad result.

A TECHNIC FOR HEPATICODUODENOSTOMY

LE GRAND GUERRY, M.D.

COLUMBIA, S. C.

Not so often as formerly but occasionally, surgeons are compelled to reconstruct the common duct. We now possess sufficient clinical data to show that whenever it is feasible anastomosis of the hepatic duct to the duodenum should be the operation of choice. Our personal experience on which this paper is based consists of 14 cases in which the bile passages have been reconstructed. In eight of the 14 cases we have been able to perform hepaticoduodenostomy. As a result of this experience there has developed a fairly definite and orderly method of operation. We do not claim that hepaticoduodenostomy can be, or should be, performed in every case of stricture of

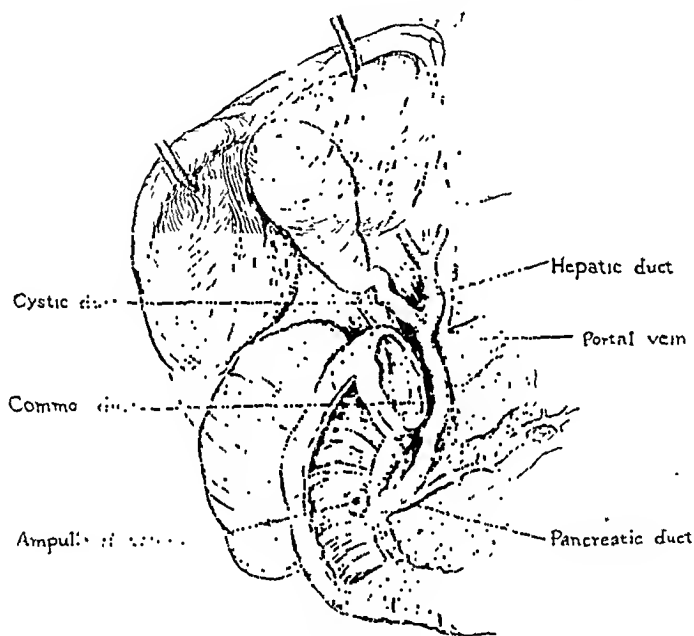


Fig. 1

Anatomy of field of operation

the common duct. Manifestly this would not be true. Much of the time, especially when the injury to the common duct occurs in the operation of cholecystectomy as shown in Fig. 2, the operation herein described is not only feasible but is the operation of choice.

All of the so called autoplasmic reconstructions of the ductus choledochus fail because of contraction of the transplanted tissue. It mattered little whether the tissue transplanted was fascia, blood vessel, or what not, invariably there was contraction of the transplant which sooner or later defeated the effort at repair. Lahey has devised a very ingenious method of turning into the duodenum the fistulous tract. This operation, while limited in its field of

usefulness, has a quite definite place, we think. Here as elsewhere and, particularly in this type of surgery, individual resource and discriminating judg-

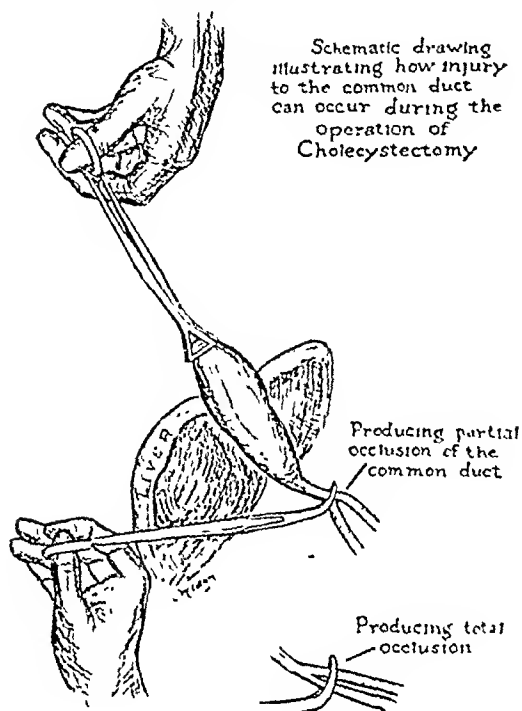


Fig 2

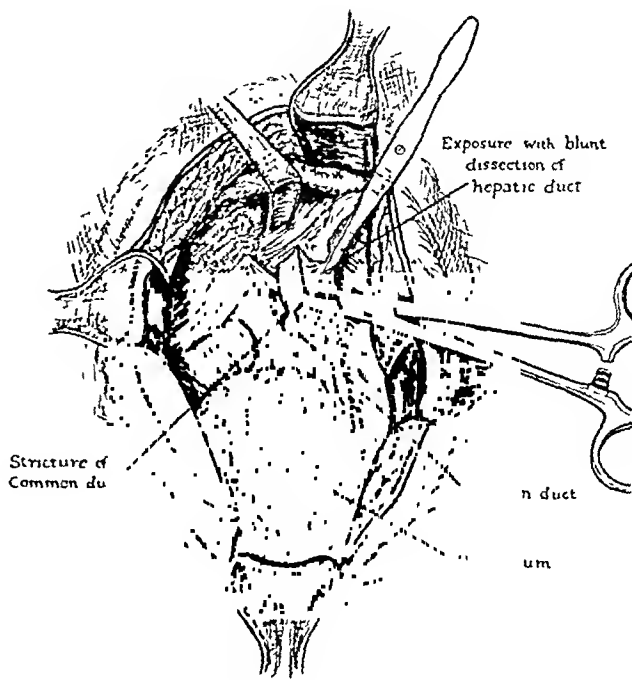


Fig 3

Method of blunt dissection

ment which holds the various methods within their normal natural fields of limitation is the sine qua non. There is no substitute, either, for what Uncle Remus refers to as "a little hard sense."

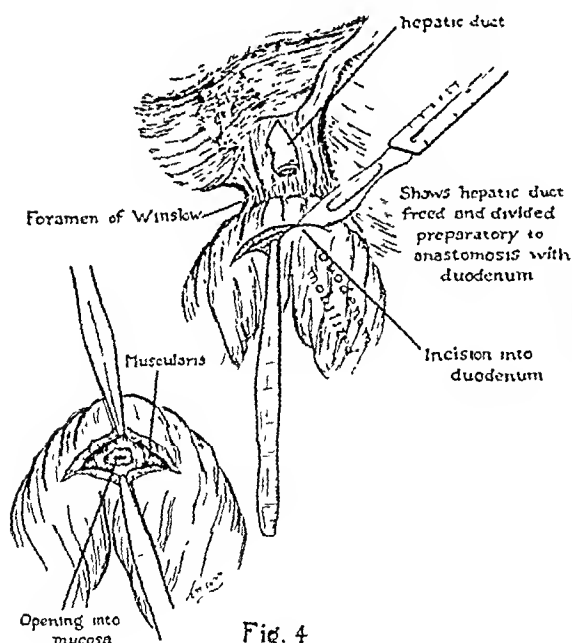


Fig. 4

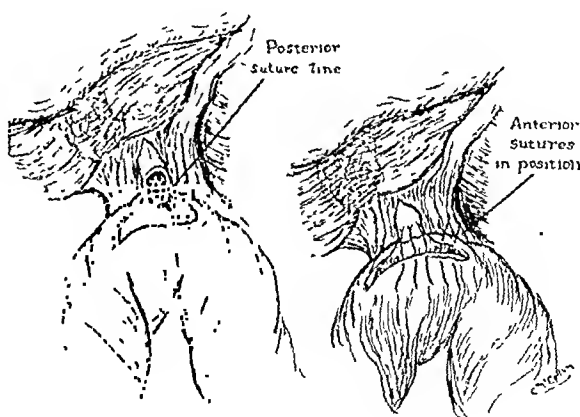


Fig. 5

Shows placing of posterior and anterior sutures

The following case description will serve as a definite illustration of the method presented.

Illustrative Case.—A white man 73 years of age presented himself complaining of pain in the abdomen, and jaundice. He had been operated upon and his gallbladder re-

moved four years before. Following this operation he was well for only a very short time. His skin remained slightly yellowish, but it was not until two years ago that he began having pain in the gallbladder region. Then followed a gradually deepening jaundice. In the past three months the pain has been quite severe, there has been more or less constant nausea and occasional vomiting, and a progressive loss in weight.

The general physical examination showed a moderate jaundice, a few coarse râles at the bases of the lungs, a blood pressure of 180/80 and a large hernia through the scar of the high right rectus incision of the cholecystectomy. There were no palpable masses in the abdomen and the other findings were normal for a man of his age. Except for a clotting time of six and one-half minutes, the laboratory blood findings were not abnormal. The urine showed a faint trace of albumin, and occasional hyaline or granular cast and, a very few red blood and pus cells.

A high right rectus incision was made under spinal anesthesia and a mass of adhesions freed from the site of the former gallbladder operation. The dissection of the common duct was extremely difficult but it was finally exposed for about 1½ cm. along its

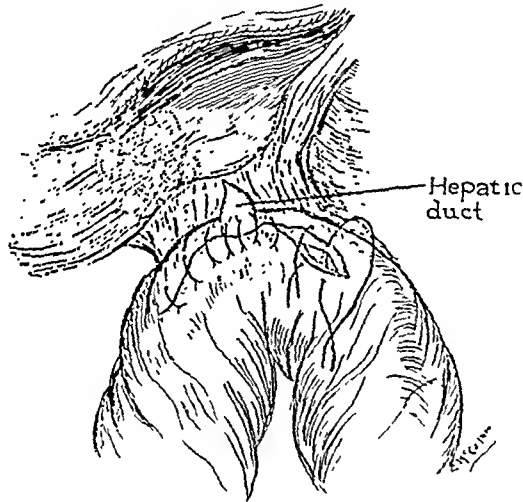


Fig. 6

Operation completed

course. It was opened just below a constriction in the duct, just at the junction of the common and hepatic ducts. The hepatic duct above this stricture was nearly 2 cm. in diameter. A transverse section was done, the distal end ligated, and the proximal end implanted in the side of the duodenum with a double layer of catgut sutures. Several small stones were removed which had pocketed in the area above the stricture. A small cigaret drain was inserted and the wound closed in layers.

An uneventful convalescence followed. The temperature never went over 100° F., and the jaundice had almost entirely disappeared by the tenth day. There was, however, a very slight yellowish tinge to the skin upon dismissal three weeks after operation though the sclerae were entirely normal in appearance.

A subsequent report on this patient's condition five years after operation showed complete symptomatic cure.

In this particular case both the postoperative hernia and the stricture of the common duct were of my own making.

The value of this paper, if any, hinges on the illustrations. With particular emphasis we direct attention to Fig. 3, which shows the method of dissecting the hepatic duct or the common duct, from the immediately adjacent

portal vein and hepatic artery. With a sharp knife we carefully incise the connective tissue sheath over the duct and complete the blunt dissection with a pair of sharp pointed artery forceps.

In almost every case the hepatic duct will be markedly dilated proximal to the stricture. This greatly facilitates its exposure once you definitely find out where you are. In practically all of the eight cases of hepaticoduodenostomy the duct was demonstrated as clearly as the illustration shows.

The further steps in the operation are best observed in the illustrations.

At other times and in other places we have reported our cases of reconstruction of the ductus choledochus particularly before the Surgical Section of the American Medical Association in June, 1918, and again in the southern number of Surgical Clinics of North America, August, 1930. This paper, as its title implies, is concerned only with the problem of hepaticoduodenostomy.

THE OPERATIVE REPAIR OF SLIDING HERNIA OF THE SIGMOID

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SLIDING herniae of the ascending, descending and sigmoid colon have been recognized for years. The absence of definite physical findings differentiating a sliding hernia from the common indirect oblique variety renders the pre-operative diagnosis practically impossible. The infrequency of this type of hernia leads one into pitfalls, unless it be recognized early during the operative procedure for an inguinal hernia. It must be realized that in a true sliding hernia, not only is the bowel carried down the inguinal canal, but also the all important associated nutrient vessels. Attempts to isolate the sac, as in the operative procedure for an indirect oblique inguinal hernia, are impossible. To misinterpret the difficulties encountered as being produced by adhesions about the sac has on more than one occasion led to a devitalization of the blood supply of the sigmoid colon, and in one case seen by a colleague in consultation, gangrene of the bowel followed such an accident. A similar disaster was reported in the *British Journal of Surgery*, and the loop forming part of the hernia was amputated before the real anatomic arrangement was recognized. Fortunately, an anastomosis in this instance resulted in recovery.

The lack of unanimity of opinion regarding the proper operative procedures which should be used in the repair of sliding hernia of the sigmoid is justification for a recital of our experience in four cases in the last few years. Previous to this group we had operated on seven cases by various procedures, with a high percentage of recurrences. This led us to a survey of the suggestions which had been put forth to efficiently deal with this technical problem.^{4, 5, 6, 7, 8} The most valuable contribution, by Moschowitz,¹ dealing with the pathologic anatomy of sliding hernia, clarified for us the basic requirements of an operative procedure which would effectively repair such a hernia. In his thesis he divides the genesis of such herniae into either a pulling or a pushing mechanism, the former producing a large hernia and the latter a smaller hernia. His reiteration that only a viscus partially covered by peritoneum can take part in a sliding hernia precluded the likelihood of the free sigmoid loop being associated with such a hernia. He stated that, while he could conceive of the sigmoid being the involved portion of the colon, he had not encountered such a condition.

The four cases which we are reporting all occurred with the free sigmoid loop being the portion of the colon which formed the apex of the hernia. All were large herniae, and it appeared to us that this was the result of a pushing mechanism, which shoved the posterior peritoneum lateral to the

sigmoid through the internal ring, and as this pushing mechanism increased, it unfolded the peritoneal leaves forming the mesentery of the sigmoid (Figs. 1 and 3). This placed the sigmoid loop at the apex of the hernia; the vessels lay behind it, and the peritoneal cavity became continuous with the bulge on the anterior wall of the mass of the hernia. This production of a large hernia by a pushing mechanism is at variance with the hypothesis which Moschowitz originally put forward.

The diagnosis of a sliding hernia may be suspected if we have a history of a hernia of long standing increasing in size, when a truss which formerly was efficient can no longer be worn because of the pain and irritation attendant upon its use, the hernia finally becoming irreducible. In two of our cases this was the definite sequence of events, and in only one of the four cases could a truss be worn without undue pain, but it proved to be ineffective in controlling the hernia. In none of these cases was the hernia strangulated, nor could we elicit any history which might be interpreted as even a partial

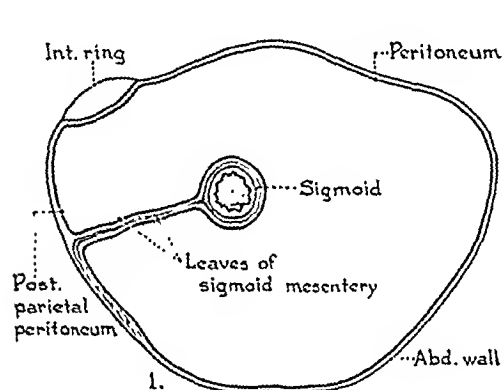


FIG. 1.

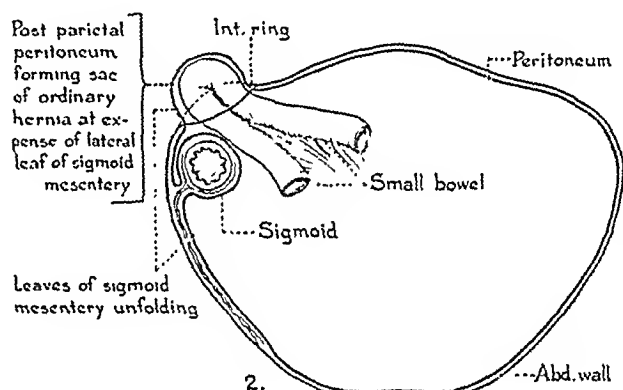


FIG. 2.

strangulation during their development. The ineffectual attempts to reduce the irreducible herniae were accompanied by an unusual degree of pain.

White² has also found these three points in cases of sliding hernia which he has encountered, namely: they seldom strangulate; attempts at reduction are ineffectual and exceedingly painful, and in his group a truss which formerly was worn in comfort had to be discarded because of pain.

While the above clinical findings may be present in an ordinary indirect inguinal hernia, if one bears in mind the sequence of the symptoms and physical findings during the development of the hernia, one may at least suspect the possibility of a sliding hernia, and thus be forewarned before undertaking the operation. To be alert to the possibility of the hernia being of the sliding variety renders its recognition relatively easy, and the operator is thus able to avoid disaster, and save himself many anxious moments while the true nature of the anatomic disturbance is determined.

With the inguinal canal open one is immediately impressed with the amount of fat which is present about the sac. The thickness of the sac, and the inability to return the contents to the peritoneal cavity, are striking. There is visible a thin layer of peritoneum in front of the sac, but the sharp crescentic border of the fundus is conspicuous by its absence. As one attempts to lift

up the sac, it is impossible to follow the continuity of the anterior peritoneal layer with a similar layer posteriorly. In the posterior area there is encountered undue vascularity (Fig. 3), which immediately should lead one to suspect this unusual type of hernia. By opening the peritoneum visible on the anterior wall of the hernia, one finds the colon occupying the apex of the sac, and the continuity of the peritoneum is over the colon and continued up along the posterior wall of the sac. We thus realize that only a small portion of the circumference of the colon is in contact with this peritoneal covering. Our experience with seven previous cases in attempting to return this bowel to the peritoneal cavity and repair the wall has been neither happy nor satisfactory. Believing that the true pathologic anatomy of this type of hernia was an unfolding of the peritoneal leaves of the sigmoid mesentery, we immediately opened the peritoneal cavity by a paramedial incision, as originally suggested by Moschowitz. On withdrawing the sigmoid into the peritoneal cavity through this new incision, the opening which had been made in the

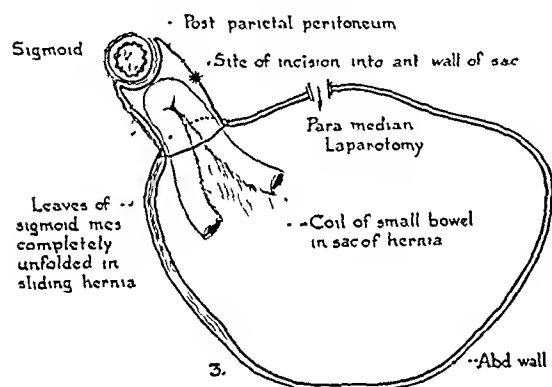


FIG. 3.

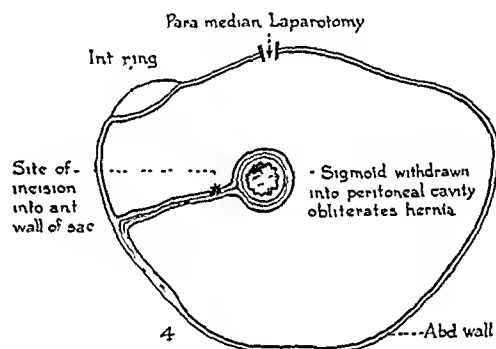


FIG. 4.

anterior peritoneal layer of the hernial sac now comes to be simply a linear slit in the peritoneum forming the lateral leaf of the sigmoid mesentery (Fig. 4). This defect is closed by a continuous suture. When the hernial wound is again inspected, we find that all evidence of hernia has disappeared; there is no redundant peritoneal sac, and we are confronted with the problem of repairing the inguinal canal, as in the ordinary operation for indirect oblique inguinal hernia.

The work of Seelig and Chouke³ directed to the relative merits of union between fascia and fascia and muscle and fascia, so favorably impressed us that for many years we adopted their suggestion of uniting fascia to fascia by suturing the medial margin of the free edge of the opened external oblique aponeurosis to Poupart's ligament and overlapping the lateral leaf of the external oblique on top of this mesial layer, behind the cord, which was transplanted external to the aponeurosis. A recent survey of our late results disappointed us by showing a high incidence of recurrences at the site of the new internal ring. We have now returned to the classic Bassini type of repair, using a strip of fascia from the external oblique, as suggested by McArthur, or the living sutures of fascia or fascial patch removed from the

fascia lata of the thigh, as suggested by Gallie. The Gallie operation is reserved for all recurrent cases, or those in which the defect at the internal ring is large, and the muscular structures atrophic.

It may be argued that to add a laparotomy to a supposedly simple hernia operation is not only unnecessary but unjustifiable. However, we submit that a sliding hernia of the sigmoid is not a simple hernia, nor is its repair a simple surgical procedure. An operation for sliding hernia carries with it not only the potentialities of immediate disaster, but an incidence of recurrence much higher than that following the operative procedure carried out for indirect oblique inguinal herniae. The delightful convalescence of our patients has not impressed us that the laparotomy is a great additional hazard. It does not prolong the bed rest nor increase the economic time loss. Indeed, the addition of a laparotomy wound is a minor procedure, compared to that required for the repair of a recurrent sliding hernia.

In conclusion, to be on the alert for the possibility of a sliding hernia of the sigmoid during operations for supposedly simple indirect oblique inguinal hernia, renders the recognition of this condition relatively simple.

The addition of a laparotomy wound in the repair of this type of hernia removes the hazard of injury to the nutrient vessels and renders a repair of the peritoneal unfolding simple and efficient. When this has been carried out, the repair of the inguinal canal may then be carried out unhampered by whatever technic has found favor with the individual surgeon.

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DISCUSSION.—CARL G. BURDICK, M.D. (New York).—In addition to the diagnostic points which Doctor Graham has outlined, a roentgenogram following a bismuth enema will reveal the presence of the sigmoid or colon in the hernial sac. At the Hospital for Ruptured and Crippled we have operated on 18 sliding herniae of the sigmoid in the last 5,000 cases, a rate of about one in every 250 herniae.

Early opening of the sac simplifies the operative procedure. The incision should be made with a sharp scalpel in the anterior and lateral parts of the sac. Careful sponging will enable the operator to recognize the musculature of the bowel or any unusual bleeding due to invasion of the retroperitoneal space, before serious damage takes place. Reduction of the bowel can be accomplished by the method of Moschowitz, as suggested by Doctor Graham, or by forming a new mesentery, as suggested many years ago by Hotchkiss.

We prefer the latter due to its simplicity and the shortening of the operating-time, as most of these types occur in patients advanced in years.

High ligation of the sac does not play the same part in the radical cure as in a simple indirect inguinal hernia, consequently a more thorough attempt must be made to repair the abdominal defect. The emergence of the cord through the layers of the abdominal wall, irrespective of where it lies, leaves a defect; and for the past six years we have completely divided and resected a portion of the cord to insure a more complete closure. We have completely divided the cord in 200 operations for different types of hernia including 14 of the sliding variety. The recurrence rate for the latter group is 7.7 per cent. In this series of 200 operations, four testicles sloughed, a good many atrophied, but 42 were recorded as normal in size, having been traced for from one to five years. In addition to the division of the cord we are inclined to use a



FIG. 5 shows a large scrotal hernia.



FIG. 6 shows the sigmoid in the hernial sac.

fascial suture repair. Our results with the McArthur method have not been so satisfactory as with the Gallie strips removed from the thigh.

Doctor Burdick supplemented his prepared discussion, with the following remarks and two illustrations:

As Doctor Graham stated, they are usually very large and we rather suspected that this might be of the sliding variety. Consequently we had a roentgenogram taken following a barium enema.

I think it is always a good plan to have a roentgenogram if we suspect a sliding hernia.

DR. A. D. BEVAN (Chicago, Ill.)—Four or five years ago I made a report of some work we had done on sliding hernia and the outstanding observations were: First of all, most of our cases have been on the right side. We came to the conclusion that one of the important factors that prevented a permanent

SLIDING HERNIA OF SIGMOID

cure was the enormous size of the neck of the sac. The other factor was the difficulty of reducing the contents of the sliding hernia into the abdominal cavity; this was true whether it was of the cecum or the sigmoid.

After operating on a number of these cases, we devised the appended method, which has been most satisfactory.

A study of the anatomy of these cases shows that the blood supply of the colon on both the right and left sides comes entirely from the inner side, and that the outer layer of the mesentery is avascular. I want to emphasize the fact that in dividing the peritoneum so that the colon can be put back into the abdominal cavity we should be careful to limit the division to the outer layer, the avascular layer of the mesentery.

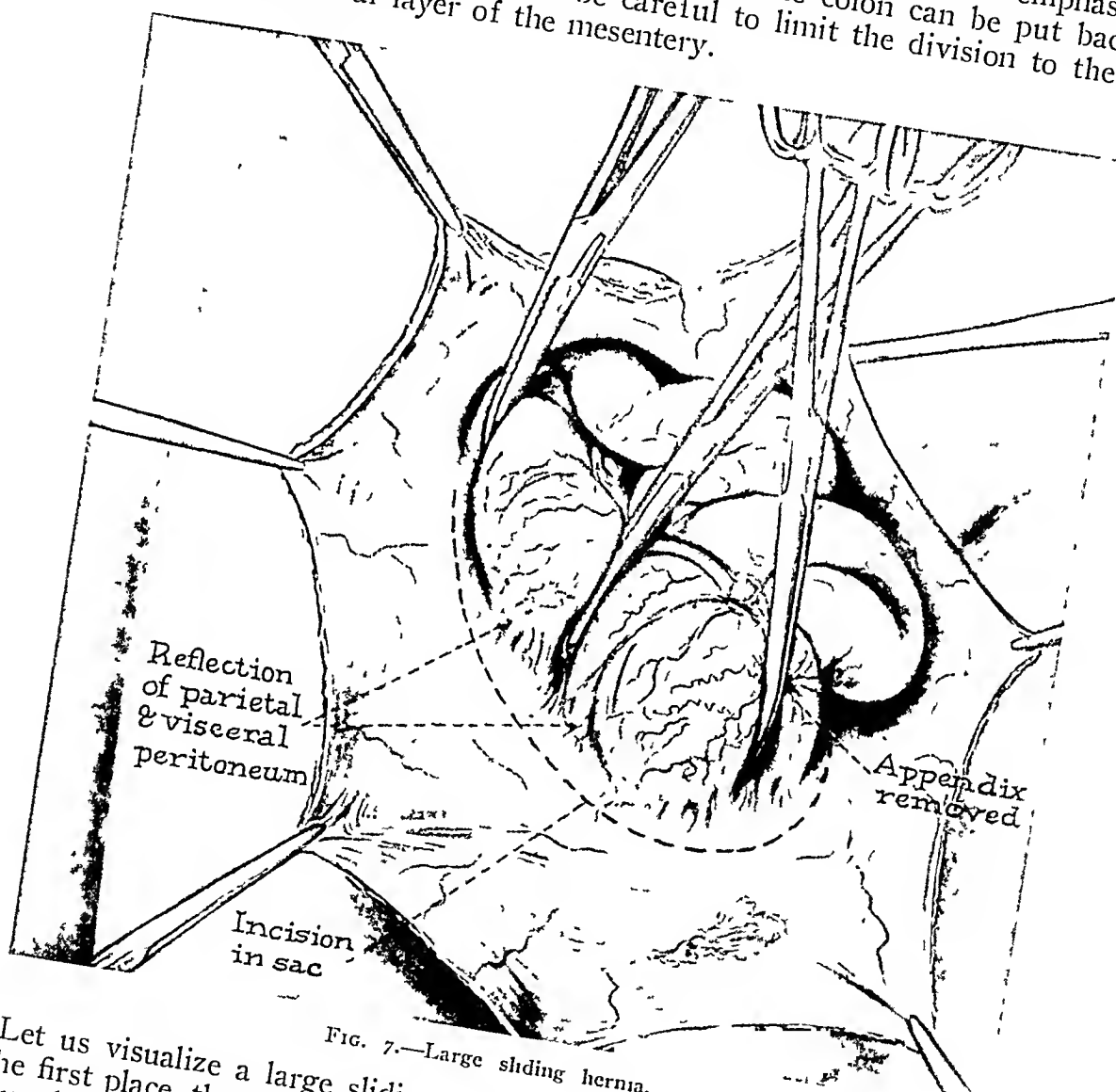


FIG. 7.—Large sliding hernia.

Let us visualize a large sliding hernia on the right side. You will see, in the first place, the enormous size of the mouth of the sac, which prevents closure by means of a ligature being of any value. In the second place, visualize the fact that in this sac we have the cecum and appendix and ascending colon and ileum. After opening the sac widely the division of the peritoneum made to mobilize the colon must be made in the avascular outer layer (Fig. 7).

After you have made the incision in the peritoneum, you then lift up the cecum and unite the peritoneal flaps with fine catgut so that you cover the raw surface of the colon completely (Fig. 8).

After you have done this, you can then return into the abdominal cavity,

the cecum and the ileum. Then the second problem is to take care of the enormous sac.

In order to accomplish this we adopted a method which we use constantly in all cases of direct hernia, and that is the method of invagination of the sac, because we have found that in the ordinary direct hernia you have also a very large neck to the sac to deal with and that there is a great tendency to recurrence after operation if the sac is simply ligated and cut off. We found in our work that in the direct hernia, by adopting this method of invagination, we have eliminated recurrence in almost all of our cases.

Doctor Graham said to me that it was difficult for him to understand the technic. It is rather difficult unless you actually see the operation done.



FIG. 8.—Peritonization completed.

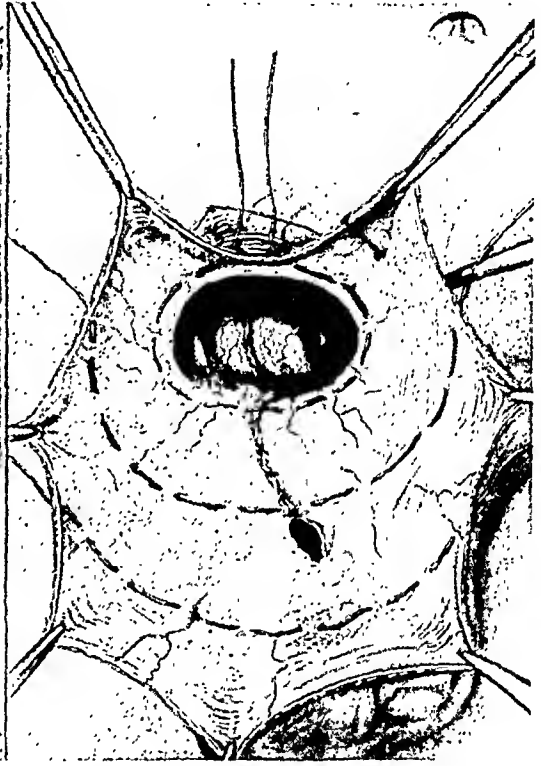


FIG. 9.—The mobilized bowel has been returned to the abdominal cavity. Three purse string sutures have been placed preparatory to reduction of the large sac.

After we have mobilized and peritonealized the contents of a sliding hernia and returned them into the abdominal cavity, the next step is the invagination of the sac into the abdominal cavity. With the sac open we put in three catgut purse string sutures. The upper suture starts on the outer side of the vertical incision in the sac, goes through the peritoneum, and comes out on the inner side of the vertical incision, the second and third sutures in the same way (Fig. 9).

This is rather an excessively large sac. Where the sac is very large, we remove the excess portion of it, but retain a great deal of the peritoneum because we want it as a pad inside of the abdominal cavity. The vertical incision in the sac is then closed with fine catgut. You see, you now have three purse string sutures. You invaginate the first part of the sac and tie the suture. You then invaginate another portion of the sac and tie the second suture, then the third suture and you have the condition as it is represented here (Fig. 10, A, B, C, D). Inside the peritoneal cavity, you have this large

piece of peritoneum folded as a pad of peritoneum at the internal ring. We have found, as in direct hernia, that this has given us more insurance against recurrence than any other method.

It is rather confusing to one who has not done this operation before, but after all, it is quite simple. I very strongly advocate this method of handling the sac in both sliding hernia and in direct inguinal hernia. You know, there is a great tendency to recurrence in both and it really is due to the fact that we used this invagination method in direct hernia in a great many cases and had

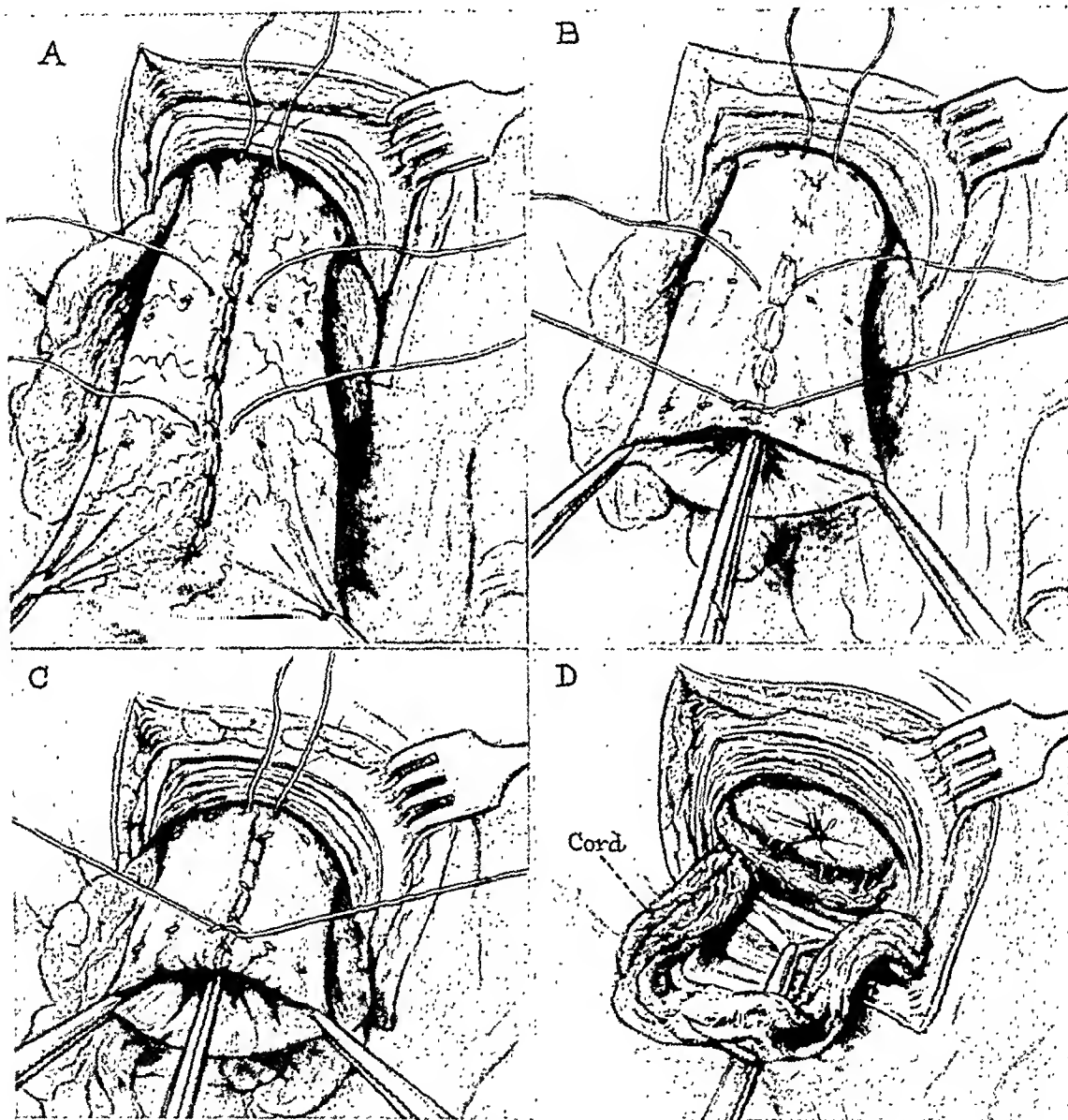


FIG. 10.—The successive steps of invagination of the sac. A shows the edges of the sac brought together with a running suture, making a complete closure. B and C show the first two steps of invagination. In D the final purse string has been tied and the sac completely turned into the peritoneal cavity.

been very successful with it, that we applied the same conception to sliding hernia.

DR. EMMET RIXFORD (San Francisco, Calif.).—I have had occasion to operate on a number of sliding herniae. Off hand it is my impression that there is little difference in frequency between the right and left side, though I believe that I have had more sliding herniae of the sigmoid than of the cecum. Most so called colossal herniae are of this nature.

CASE REPORT

Mr. K., aged 49, was a barkeeper; he therefore did not have to get about very much. His right inguinal hernia kept enlarging until he was obliged to support it with a great leather sling hung from a harness about his shoulders. It was so large that he could not bring his knees together within a foot or more. He said "it finally got to be something of a drag on him." When he came to us in 1915 the sac reached well below his knees. Sac and contents weighed approximately 50 pounds. Urination was through a long tunnel with about a foot of balanitis and the skin of the scrotum was the seat of a dermatitis giving considerable risk from sepsis.

Operation showed the sac to contain about a gallon of fluid, practically all the abdominal contents except the liver, kidneys and stomach; and actually the entire intestine from the pylorus to the sigmoid was in the sac. I think Doctor Bevan would have been interested in attempting to pucker up the sac. The intestine had been out so long that it had practically lost the right of habitation. We took away the entire omentum and then doubling the man up by flexing his thighs, in order to overcome the lumbar lordosis, we secured considerably more room in the abdomen and finally succeeded in feeding the intestines back into it. We then cut away a considerable area of skin and a large excess of sac. After all that is all that need be done in the management of the sac and is best done after replacement of the hernial contents. Care of course must be exercised not to cut across either the intestine or the mesenteric vessels, suturing the edges of the peritoneum at what might be called the neck of the sac as in any other laparotomy.

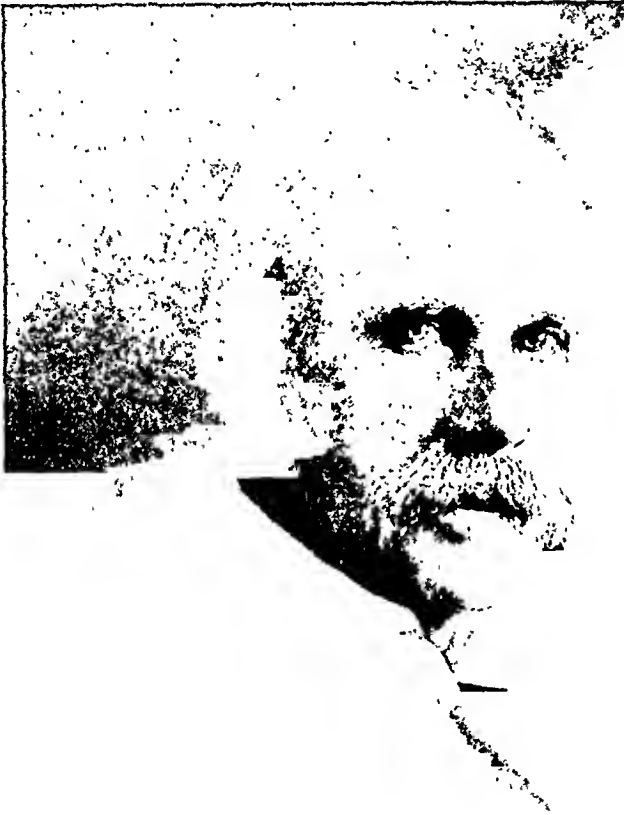
Of course in this case there was a great deal of adventitious fibrous tissue; various fasciae were greatly hypertrophied. We used these tissues to close the wound by a process of imbrication, of four or five different layers. For some hours we were worried by cyanosis doubtless due to pressure on the diaphragm, but this gradually disappeared. After a somewhat stormy convalescence due to infection in which the testicle sloughed, the man recovered. Fifteen years afterwards he returned with an enormous varicose ulcer of his leg. The hernia had not recurred.

MEMOIR

LEWIS STEPHEN PILCHER

1845-1934

SOMETIMES there appears among his fellows, whose lives and work are for the most part fragmentary, episodic, incomplete, a man whose whole long life responds to one clear call. Such was Lewis Stephen Pilcher. Dying in



LEWIS STEPHEN PILCHER, M.D., LL.D.

his ninetieth year, he left behind him an unbroken record of faithful service in surgical practice, in surgical letters and in the impress of his character upon his associates and his time.

He was born in 1845, the second son of Elijah Holmes Pilcher, a Methodist preacher in Michigan. Elijah Pilcher was himself no ordinary man. An

Evangelist-Administrator, as his son has said, "of strong and athletic build, a silent, thoughtful and studious man." A pioneer Evangelist with a horse, saddle-bags, and his beloved Greek testament, he traveled over the whole southern portion of Michigan "interested not only in the affairs of his own denomination but also in everything that involved the welfare of the nascent State."

In his work as a founder of churches and an administrator of ecclesiastical affairs, he often found himself confronted by questions of law. So he registered himself as a student of law, and at odd times, and as an incident to his ministerial labors, pursued his studies so well that he was admitted to the Bar. Later on when he found himself stationed at Ann Arbor he was able by midnight and early morning study to graduate as Doctor of Medicine. This was in 1859. Lewis S. Pilcher has said "My own thoughts of a medical career date from this period. My father took me with him into the dissecting room and the chemical laboratory and gave me my first insight into the mysteries of the human body and the wonders of chemistry. But a few years later I was myself working as enthusiastically in both departments as my father had done before me. It was as natural that I should grow up into medicine as it was that a fledgling should fly when it was pushed out of the nest by the mother bird."

There were four other children and the salary paid by the most important Methodist church in Michigan in 1852, when Elijah H. Pilcher was its pastor, was \$300. Throughout his career he never received a salary of \$1000 a year—and yet his children were fed, clothed, and educated. "The chief agent in the successful accomplishment of such a result was the wife and mother, who, by her prudence, industry, frugality, and personal labors so cherished and amplified the meager support received from the church as to practically, yearly, repeat the old miracle of the Widow's Cruse of Oil." A sturdy, healthy, happy family brought up to help themselves and each other with an example always before them of studious, earnest effort. Here in his own home he received most of his early education. His father taught him Latin and Greek, his mother saw to his grammar, algebra and natural philosophy. One year in high school at Ann Arbor and he was ready for the University of Michigan, in the fall of 1858, at the age of 13. "I enjoy the distinction," he said, "of having been the youngest matriculant and the youngest graduate in the history of the institution."

Four years in college, living at home, a fact he partly deplored, but which was probably better for him than he knew during those turbulent war time adolescent years. Expelled from the University for a boyish prank, reinstated evidently by family influence, graduated and beginning the study of medicine and then swept into the war. A hospital steward subject to the vagaries of military orders, the first years away from home, no father, no books, half house surgeon, half superintendent, a good commanding officer and a cold douche of reality. Duty in a Missouri border plantation big house converted into an hospital with the vicissitudes of the last futile guerrilla

raids of a dying confederacy; mustered out, more medical studies soon completed, doctor in medicine. Why not go back to the Service? Try the Navy. Too young, not yet 21, insufficient clinical experience! Back to Michigan and medical practice. A try out in Flint. No patients. Try Schwartz Creek. General country practice, an opportunity to help the exchequer by teaching school. Moderate success. An opportunity to take a house surgeonship at Detroit. Grasped. Taken. Able chiefs—Farrand and Andrews, Jenks and McGraw: "at the flame of their enthusiasm and ambition, I lighted my own torch."

A year in New York at Bellevue and now better fortune—a commission in the Navy as Assistant Surgeon, ordered for duty at the Naval Hospital in Brooklyn. Four years in the Navy, some shore duty, some at sea, some experience with yellow fever, and romance and marriage with a Brooklyn girl; a baby coming and orders to go to sea. It must be done! Resignation from the service and the establishment of a practice in Brooklyn. Once more frugality and patient effort in that rapidly growing conglomerate small town, suburb of the great city. A foothold in general practice, recognition of ability and of character by important citizens and by the leaders of the profession. Friendship with Skene and Fowler and a realization of the possibility the town of that time offered of *otium dignitate*, unobtainable in the city beyond the river, kept him at rest.

An appointment as teacher of anatomy in Long Island College of Medicine fortified his resolve. He labored for a surgical appointment but found his somewhat uncompromising personality in the way, and then a break! An invitation to assist in organizing the new Methodist Hospital, a well endowed institution; to carry on in surgery and in medicine the recent advanced ideas of the great new age. A period of foreign study and 20 splendid years of professional accomplishment and of inspiration to younger men.

Two stout sons, raised in the profession and then when his long service most deserved reward, his hospital betrayed him. He resigned, converted his home into a private hospital and with his boys, carried on, developed his and their high ideals of surgery as it should be and for ten short years won the appreciation and acclaim of his colleagues and the city. Broken by the sudden death of the elder son, while the younger was at the Mexican border with the army, the hospital was transferred to other hands. During those years however he had shown that a doctor's workshop could be maintained in the highest standard of scientific efficiency, without assistance or interference by meddling laymen.

His later years were enriched by his activities in the G.A.R., mustered into U. S. Grant Post in 1907. In five years he was elected Commander, in five years more Commander of the Department and at the end of a third five year period, Commander-in-Chief of the entire Grand Army. It gave him great satisfaction.

He was a sedulous collector of old masters in medicine and in 1918 published a quarto volume of 200 pages entitled A List of Books by Some of

the Old Masters of Medicine and Surgery Together with Books on the History of Medicine and on Medical Biography, which were in his own possession.

His own contributions to the literature of direct surgical effort were many and fill pages of the *Index Medicus*. The earliest were those in connection with the procedure of tracheotomy in diphtheritic croup, now fortunately an obsolete necessity. In the late '70's and '80's, however, this was not the case and his studies of the anatomy, surgery, etiology and epidemiology of that now forgotten subject might still well serve for models of studies of conditions with which we struggle—awaiting the advance of knowledge and their disposition in the limbo of oblivion.

He contributed to the literature of Injuries to the Wrist and of the Treatment of Wounds. His papers on the Surgery of Cancer of the Breast; of the Surgery of the Colon; of Prostatic Hypertrophy and Hemorrhoids and many others, reflect the scholarly consideration of his own cases in the light of the recorded experience of others. He contributed often to the literature of hospital organization and to the History of Medicine and in his *Autobiography—A Surgical Pilgrim's Progress*—left a record of his origins, the sources of his ideals, his inspirations and his indefatigable industry.

The most valuable portion of his works was, however, anonymous. How many famous papers owe their acclaim to his unselfish editing, or to his preliminary suggestion? How many juvenile asininities owe their non-existence to his strict and honest rejection. Faithful are the wounds of a friend. The Editor of the *ANNALS OF SURGERY* was faithful.

A few years after coming to Brooklyn, and no doubt influenced by his associations as a teacher of anatomy, he and others formed a club for the promotion of the practical study of anatomy and surgery, by the maintenance of proper rooms for the pursuit of such studies, by the formation of a museum, by the accumulation of a library, by lectures and demonstrations and by stated meetings for the discussion of subjects pertaining to that special field. This was the Brooklyn Anatomical and Surgical Society, of which Pilcher was the first President and George R. Fowler the Secretary. Its transactions for the first year form Volume I of the *Annals of the Anatomical and Surgical Society*. Arrangements for publication were made with Putnam's Sons as a monthly journal. At the end of a year its name was changed to that of *Annals of Anatomy and Surgery* and under the joint editorship of Pilcher and Fowler it carried on until January, 1884, when, its joint editors and owners having planned a trip to Europe for study, publication was suspended. On Pilcher's return he was visited by James H. Chambers of St. Louis, the publisher of the *Weekly Medical Review*, and plans were discussed for the founding of a "strictly surgical journal of a high class." Apparently Pilcher approached the suggestion with eagerness. "Now here was a flat proposition from a hard-headed acute business man who practically proposed to fully assume all the responsibility, labors and expenses of publishing such a

periodical, while absolute control of the scientific contents of the journal and censorship of the advertising pages were guaranteed to me."

The first number of the *ANNALS OF SURGERY* was published in January, 1885. In January, 1892, the imprint of the University of Pennsylvania Press of Philadelphia was substituted for that of James H. Chambers of St. Louis. In the Spring of 1897 the *ANNALS* was acquired by the J. B. Lippincott Company of Philadelphia who have continued to publish it since that time. With the collaboration of American and British surgeons, too many to mention in detail and by name, the reporting of the transactions of the American Surgical Association, the New York Surgical Society and the Philadelphia Academy of Surgery, its careful and faithful editorial policy has been its fame. He states, "Nearly every line of all these volumes has passed under my own eye, has been corrected, often extensively edited and always prepared for the compositor's final proofs, read and the completed making up into monthly numbers decided upon by myself, for such is the duty of an editor."

When the *ANNALS OF SURGERY* began in January, 1885, there was no other purely surgical journal in the English tongue—there are many now of many variations. The *ANNALS* has kept to its well defined course—a Monthly Review of Surgical Science and Practice, until a few short months before his death, under one guiding hand. A great achievement! A monument more lasting than bronze.

JOHN E. JENNINGS, M.D.

BOOK REVIEW

MODERN OPERATIVE SURGERY: Edited by G. GREY TURNER, M.S., F.R.C.S. (Eng.), Vols. I and II, 2nd edit. Baltimore: William Wood & Co., 1934.

ONLY one who has visited Grey Turner's Clinic in New Castle-upon-Tyne can fully appreciate the two volumes under the above title. That Clinic, dominated by one man, indefatigable, working in all the major fields of surgery, with apparently few associates, is epitomized in these two volumes. For although there are many authors taking part in the work, Grey Turner is the outstanding figure and gives the work an individual character, even though he has attempted faithfully to carry out the spirit and purpose of H. W. Carson, the editor of the first edition.

The work as a whole is based upon Carson's conception of the first edition. One wonders at some of the arrangement and order of the subjects. As in all systems where the several topics and chapters are written by different individuals there is a considerable variation in style, method and virtue of the material discussed. Some chapters are much more comprehensive and up-to-date than others. A criticism that can be made of other English text-books is the preponderance of English statistics and the lack of adequate personal follow up data. More American authorities are quoted than continental. One notes a very definite tendency to quote figures and reports from literature that we would consider quite out-of-date. Quite justly, because of the large number of cases and his personal knowledge of the surgeons working there, the Mayo Clinic is most frequently quoted.

Taking some of the chapters in the order given, the reviewer has noted his impressions; thus R. C. Elmslie writes the chapter on orthopedic surgery; this includes general orthopedics, amputations and operations on tendons. There is very little, if any, discussion of simple fractures. Operations on bones are discussed by E. W. H. Groves, and those on joints by P. J. Verrall. In the discussion of tuberculous joints and bones one is surprised to find so little consideration of Hibbs' fundamental principles of immobilization by fusion and his remarkable results are not quoted. The Boston School is also given little appreciation. In the procedures for chronic suppurative osteomyelitis, the Orr vaselin pack method so favorably received in the United States, is not mentioned.

The chapter on thoracic surgery is written by J. E. H. Roberts. Of the more recent advances made in this field, Shenstone and Janes' operation for lobectomy is rightly emphasized. Nothing however is said about total pneu-

nectomy for carcinoma. Platts' chapter on surgery of the nerves is remarkable for the very complete report on the results of operations for the repair of nerve injuries. Drummonds' chapter on vascular surgery, revised by Grey Turner is comprehensive and shows the lessons taught by the Great War. Sampson Handley in his original and sound fashion discusses the principles of operative treatment of tumors in general and of the breast in particular. These chapters are thorough, sound and constructive.

The latter half of the first volume, given over to abdominal surgery, is largely written by Grey Turner and reveals his wide experience, his rare judgment and special interests. The chapter on abdominal injuries is noteworthy, as are the chapters on the appendix, the intestinal and biliary tracts. Walton contributes the chapter on gastric operations. It is surprising that, with his wide experience he has not had better results in gastric resection for cancer. He also writes the chapter on ptosis and intestinal stasis. It is worth noting that he discredits the operation of colectomy and the theories upon which it is based. Grey Turner gives an unusually comprehensive discussion of cancer of the colon and rectum, and includes a personal communication from Miles on his one stage abdomino-perineal removal of the rectum. The chapter on surgery of appendicitis and peritonitis is excellent and shows Grey Turner's experience and surgical judgment.

In the second volume are included the surgery of the specialties of the eye, nose and throat, neurologic fields, urology and gynecology. These chapters are written by able men in these fields. One is surprised not to find in the section on gynecology, by Giles, any discussion of radium therapy for cancer of the cervix. In the section on urologic surgery by Sir John Thompson-Walker and John Everidge there are remarkably interesting tables on the immediate and late results following the major urologic procedures. Especially to be commended is the fair presentation of the relative merits of suprapubic and perineal prostatectomy. One is surprised that continuous suction is not advocated postoperatively in cases of suprapubic cystostomy.

Tanner in his chapter on surgery of the neck gives much space to the radical removal of tuberculous nodes but none to the reduction of the disease by eliminating bovine tuberculosis. He does not mention the use of roentgen ray therapy.

Walton writes the chapter on the thyroid. There is little, if any, originality in his technic and a great lack of follow up data on his own cases. He gives only half a page to the discussion of hyperparathyroidism. The discussion of the surgery of the sympathetic nervous system by Geoffrey Jefferson is unusually well presented, up-to-date and adequate.

As a whole these two volumes represent British surgery at its best. Because of Grey Turner's travel and broad interests in Continental and American Clinics this system is much more cosmopolitan than any other English text on surgery. The illustrations are for the most part well chosen and well exe-

cuted. The diction and style, as in all British text-books, is superior. The one glaring fault noted is the lack of personal follow up data by the individual authors. This is only partly compensated for by the statistics collected from the literature.

ALLEN O. WHIPPLE, M.D.

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TRANSACTIONS of the AMERICAN SURGICAL ASSOCIATION

MEETING HELD IN BOSTON, MASS.

THE DEVELOPMENT OF A NEW BLOOD SUPPLY TO THE HEART BY OPERATION*

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CLEVELAND, OHIO

FROM THE DEPARTMENT OF SURGERY OF THE WESTERN RESERVE UNIVERSITY SCHOOL OF MEDICINE AND THE
LAKESIDE HOSPITAL, CLEVELAND, OHIO

Two relatively small arteries supply the most vital muscular structure of the body. This muscular organ is in constant motion, and to make its movements free and frictionless it is enclosed in a moist envelope of mesothelium. In providing man with this anatomic pattern Nature so frequently has deprived him of an important compensatory mechanism, namely, the ability to develop an adequate collateral blood supply to this organ. The heart is anchored in the body by the great vessels at its base, and while the entire surface of the heart is in direct contact with adjacent structures it has a minimum of direct continuity with the rest of the body. The only continuity that the heart has with the rest of the body is through the walls of the great vessels, some fat, a few nerves and lymphatics that constitute its anchorage, and these structures are relatively avascular tissues. This anatomic arrangement has made the heart a defenseless organ when its normal blood supply is interrupted. The appalling incidence of sudden death from heart failure attests to the destructive nature of coronary closure. Under normal conditions the myocardium receives practically all its blood through the left and right coronary arteries. The thebesian channels opening directly from the left ventricular cavity offer a second possible source of blood supply.¹ The importance of these channels has been the subject of argument. It has been claimed by some that the flow through the thebesian vessels is of little importance. This statement is based on the assumption that the thebesian channels are compressed, perhaps completely collapsed, by the tension of contracting muscle fibers during systole when the pressure in the ventricular cavity is being built up, and as these channels open during diastole the

* Some of the experimental data were presented in an address to the Caduceus Honorary Society of the Emory University Medical School on May 17, 1934.

pressure in the ventricular cavity synchronously falls. The third possible source of blood supply to the heart is through the extracardiac anastomoses that are present in the tissues at the base of the heart.² When the blood flow through the coronary arteries is reduced gradually, compensatory mechanisms are established. Complete closure of a major coronary artery is compatible with life, if the closure takes place sufficiently slowly. Indeed, complete closure of both major coronary arteries may be compatible with life,³ but the number of times that the process of occlusion has gone on to completion in each of the two major coronary arteries is excessively small. The occlusion must occur at such a rate as to permit the other sources of blood supply to develop. Usually while this substitution is being made, life is snuffed out like a candle flame.

I have been interested in the heart as a surgical organ since 1923, and during this period of time a rather extensive background of surgical experimentation on the heart has been accumulated, as the result of over 1200 experimental operations which have been done by my assistants and myself. I made the observation several years ago that blood vessels extended between the heart and an adherent scar. At that time Dr. R. A. Griswold⁴ and I were interested in studying chronic compression of the heart produced experimentally and we were trying to resect an adherent scar from the surface of the heart. In so far as these small vascular connections between the heart and adherent tissues were concerned, we simply noted their presence. At that time they had no other significance for us. Last November, while a compressing scar was being resected from a human heart, a broad band of scar extending from the base of the left ventricle to the parietal pericardium was transected. Brisk bleeding occurred from the cut ends of the scar and the bleeding was more brisk from the cardiac end than from the pericardial end. This was the first direct observation made at the operating table that blood actually flowed between myocardium and adherent tissues. This observation had now assumed new and additional significance because in the meantime we had been attempting to produce a collateral vascular bed to the heart experimentally. This observation confirmed our belief that vascular connections between heart and adherent tissues could be produced in the human being. I desire to give credit to Dr. Alan R. Moritz for directing my attention to the subject of vascularization of cardiopericardial adhesions. Moritz, Hudson and Orgain⁵ not only demonstrated anatomically the presence of blood vessels in cardiac adhesions by the injection of carbon particles into the coronary arteries but also Doctor Moritz believed that under certain conditions these blood vessels might function and become an important source of blood supply to the heart. He directed my attention to a case reported by Thorel in 1903. This patient had complete obliteration of both major coronary arteries, and Thorel suggested the possibility of the heart receiving a supply of blood through adhesions that were present.

Could the heart be given a new source of blood supply by operation? I carried out the first experiments in an attempt to study this problem in

February, 1932, and shortly thereafter Dr. V. L. Tichy collaborated with me, not only in the technical surgery that was involved but also in the solution of many problems.⁶ Doctor Moritz followed the work with interest and gave us valuable suggestions concerning the injection and study of the specimens.^{7, 8} In these experiments the collateral vascular bed consisted of parietal pericardium and pericardial fat. The epicardium and the lining of the parietal pericardium were removed with a burr because it was our belief that these structures acted as a barrier to the growth of blood vessels into the heart. The results of these experiments were as follows: (1) Almost total occlusion of right and left coronary arteries near the aorta was compatible with life if the heart had been provided with a collateral vascular bed. The occlusion of arteries was produced by silver bands which were compressed in stages at repeated operation. (2) Dye penetrated the myocardium through the collateral bed, and we assumed that if particles of dye entered the myocardium as freely as they did, that blood also flowed into the myocardium through these vascular channels. We believe that we succeeded in giving the heart a new source of blood supply and that this was sufficient to maintain cardiac function. (3) A pressure-differential was necessary to promote anastomosis between the cardiac and extracardiac vascular beds. In other words, a physiologic need for blood in the myocardium was necessary for such anastomoses to develop. The physiologic need for blood was produced by occlusion of the major coronary arteries by silver bands which were placed around the arteries and which were compressed in stages at successive operations. (4) The development of anastomoses between the myocardium and the collateral bed was demonstrable three weeks after operation. More recently we have succeeded in demonstrating anastomoses between extracardiac and cardiac beds two weeks after the bed was applied to the myocardium.

During the past eight months additional experimental operations have been carried out with the assistance of Dr. Ernest Bright and Miss Alice B. Maltby. In these experiments pedicle grafts of muscle were used together with the pericardial and mediastinal fat for the vascular bed. Omentum was also brought up through an opening in the diaphragm and sutured to the heart. These experiments have not yet been published but I shall refer briefly to some of the results:

(1) Anastomoses readily develop between skeletal muscle and cardiac muscle provided the normal blood supply to the heart has been reduced. If the coronary arteries were not partially occluded the anastomoses between omentum or skeletal muscle and myocardium, although present to some extent, did not become well developed.

(2) A collateral vascular bed gives the heart partial, but not complete, protection when the right coronary artery is occluded in one stage. When the descending ramus of the left coronary artery is ligated in one stage, the degree of protection afforded by a collateral vascular bed is slight. The conclusion that can be drawn is that a collateral vascular bed protects the heart when the right coronary artery is occluded in one stage. The larger

the coronary artery occluded, the less is the protective effect. The evidence, however, was definite that the presence of a collateral vascular bed protected the heart from the ravages of sudden occlusion of a major coronary artery. In this respect the operation becomes a prophylactic measure, and if the experimental data can be applied to patients with coronary sclerosis it would seem that this operation should be done early in the course of the disease, before replacement of myocardium by scar tissue and fat has taken place or before the heart has been brought to a standstill by occlusion.

(3) The right coronary artery, the ramus descendens of the left coronary artery, or the ramus circumflexus of the left coronary artery, can be ligated successfully almost as a routine if the ligation is carried out in two stages.

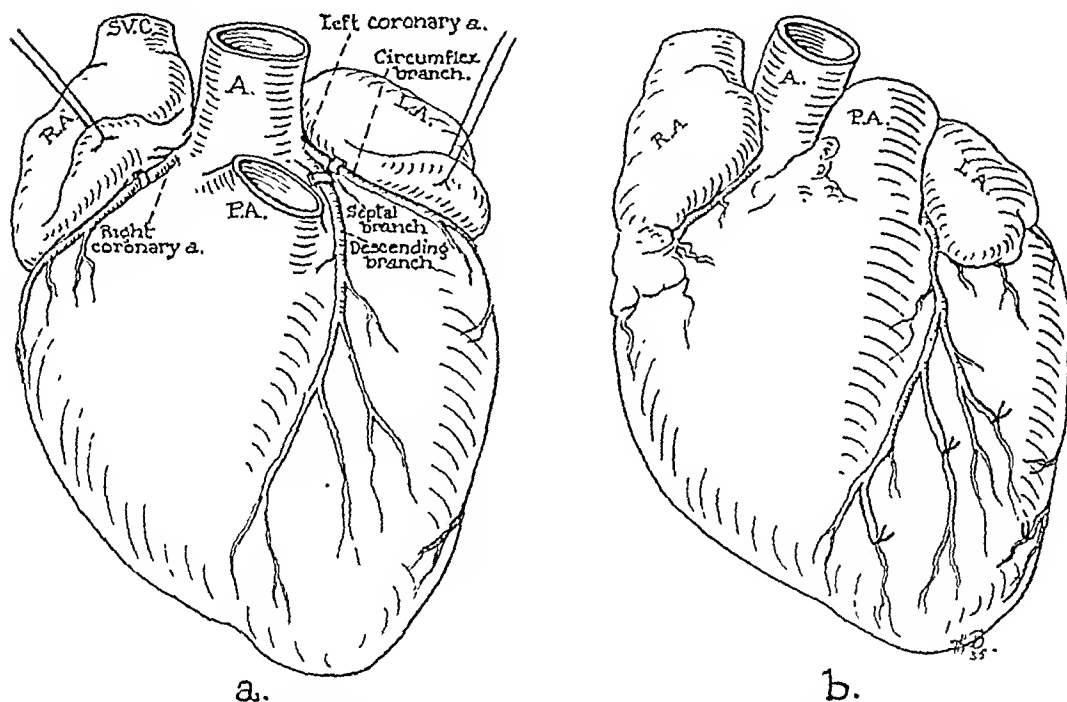


FIG. 1.—Two types of operations are shown: (a) shows the usual sites where silver bands were applied to the coronary arteries. A reduction of 30 to 50 per cent in the cross sectional area of these three arteries was compatible with life. (b) shows another type of experiment. Four or five peripheral branches of the coronary arteries over the apex of the heart were ligated. This experiment was always fatal. In (a) the reduction in total coronary blood flow was considerably greater than in (b). The heart cannot tolerate ischemia of a severe degree even though the area of ischemia is small. The collateral bed produced by operation can transport blood to such ischemic areas.

The explanation for this is that the reduction in blood flow brought about by the partial constriction of this vessel—and as little as 20 per cent of the cross section is efficacious—is compensated for by the development of collateral vessels. After this compensatory mechanism has been established, complete occlusion of the artery does not produce complete ischemia of the muscle. The myocardium remains viable after complete occlusion and additional channels become established.

(4) Distribution of blood to every part of the myocardium is of vital importance. If one relatively small portion of the myocardium is rendered ischemic by the peripheral ligation of four or five arterial branches, ventricular fibrillation develops and this is routinely fatal (Fig. 1). An equal

distribution of blood to the myocardium is essential for maintenance of function.

(5) The collateral vascular bed is functional not only in making a new source of blood supply available to the heart but it also helps to distribute blood to various portions of the myocardium. In this respect the collateral vascular bed produced by operation acts as an anastomotic bridge that transports blood from the bed of one coronary vessel to the bed of another coronary vessel where the blood flow is deficient.

The question naturally arises as to whether or not the presence of the new vascular bed might interfere with the movement of the heart. The importance of adhesions to the heart has been greatly overemphasized in the past. Cardiopericardial adhesions usually are silent lesions of little or no clinical significance. In none of our experiments did we find that the circulation was in any way embarrassed by these adhesions. Adhesions to the heart can embarrass the circulation in several ways: (1) A constricting bed of scar tissue may produce chronic cardiac compression. Adhesions in this clinical syndrome are entirely incidental and of no significance. (2) Adhesions between the heart and chest wall may act as a harness through which the heart pulls and expends energy. In our experiments the heart was not so extensively and intimately bound to the chest wall as to produce embarrassment. (3) The heart may be sharply angulated from its normal axis by such adhesions so that it cannot effectively function.

With this experimental work as a background it was decided to attempt to apply the data to a patient suffering from coronary sclerosis. To select a satisfactory case was not without difficulty and then to have the selected patient give his consent to have an operation performed on his heart (an operation that had never been done before on a human being) required something of the heroic spirit. For this reason I wish to mention the name of the patient, Joseph Krchmar, of Chardon, Ohio. I believe he has made a contribution to surgery. I also want to give credit to his physician, Dr. Walter Corey of Chardon. Doctor Corey had the imagination to see the possibilities of the experiments and he made a serious attempt to secure a patient for the operation. I also want to thank the internists, Dr. Joseph T. Wearn and Dr. Harold Feil. Doctor Feil is collaborating in the clinical aspects of this work.

CASE REPORT

J. K. was admitted to the Lakeside Hospital February 3, 1935. He was 48 years old, a white male, married, formerly a coal miner, more recently a farmer. His complaint was pain in the chest, over the heart, to the left of the sternum. He remembers the onset of the pain distinctly. A sharp pain appeared suddenly over the heart while he was at work nine years ago. It was accompanied by dyspnea and dizziness. After this initial attack he went back to fairly heavy labor until five years ago. Then, because of repeated attacks of substernal oppression, he moved to a farm. The precordial oppression was accentuated after meals. The patient claims that he had not done heavy work for the past five years, but he has done such things as plowing. During the last year or two he suffered from attacks of sharp, knife-like pains over the heart. These radiated to the left shoulder and down the left arm to the elbow. During these attacks of pain

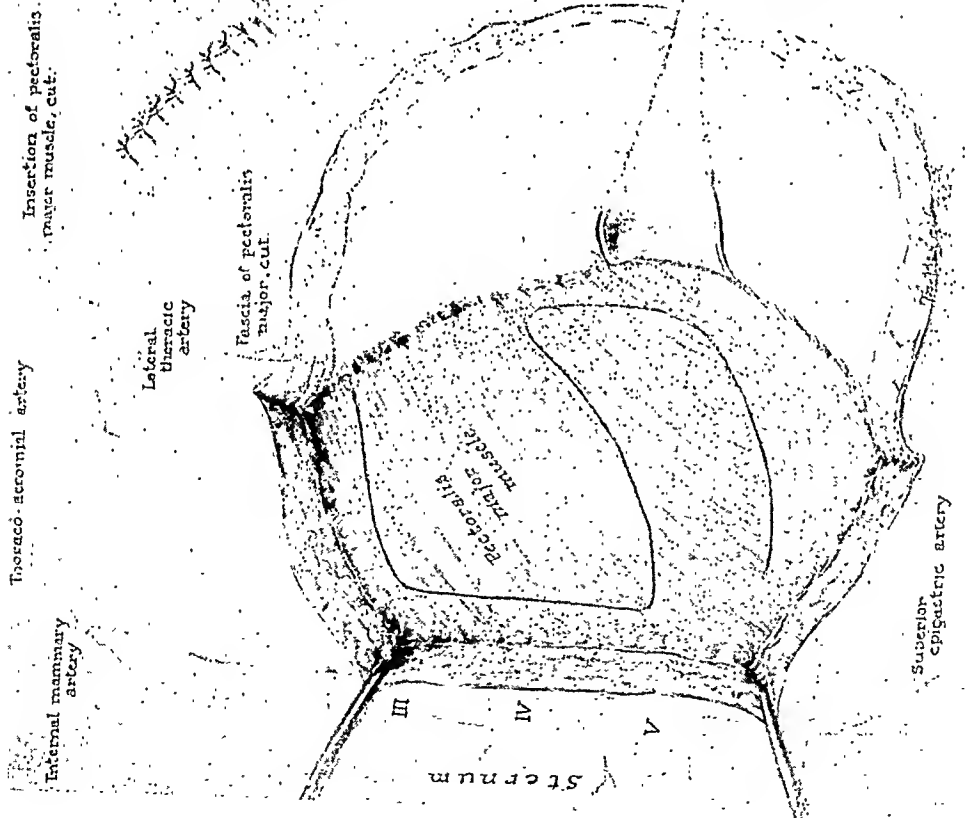


FIG. 2.—The insertion of the pectoralis major muscle was incised. A flap of skin and pectoral fascia was turned laterally. The pectoral muscle was incised as shown. This provided a pedicle graft of muscle with its attachment lateral to the sternum.

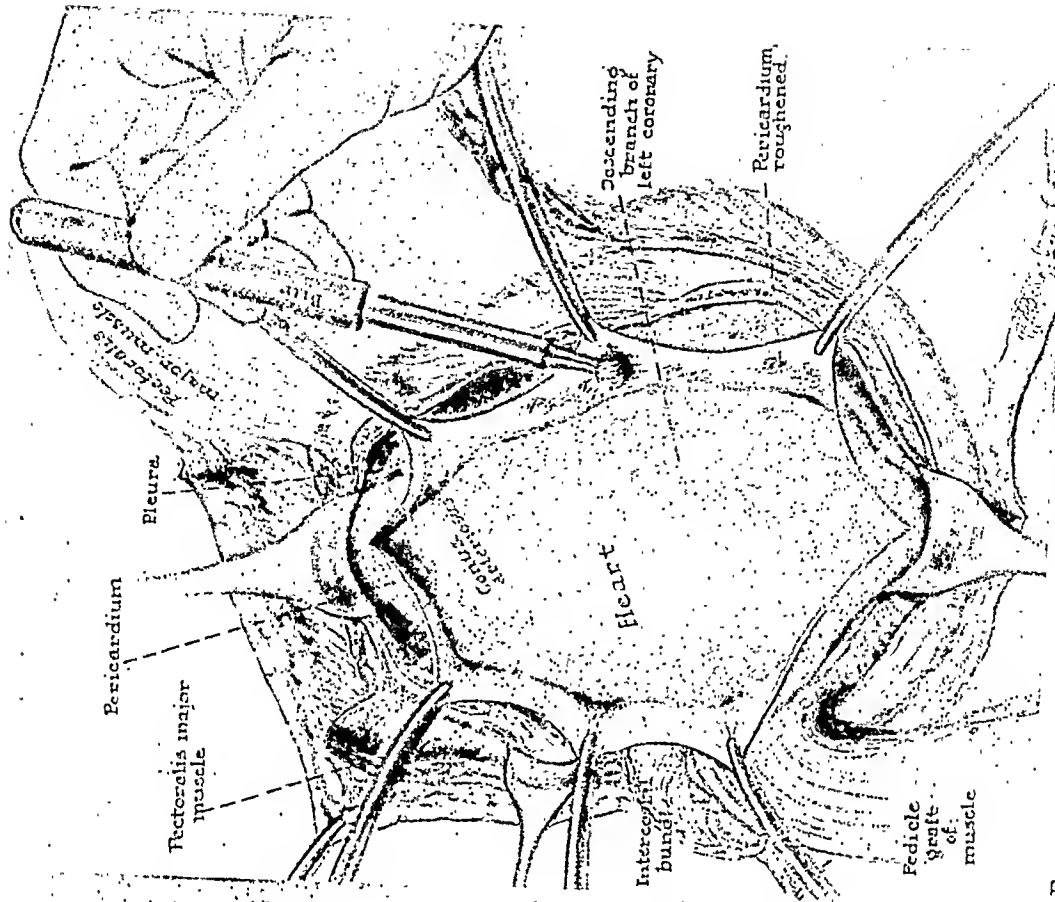


FIG. 3.—The pericardium was opened. The inner surface of the pericardium is roughened with a burr.

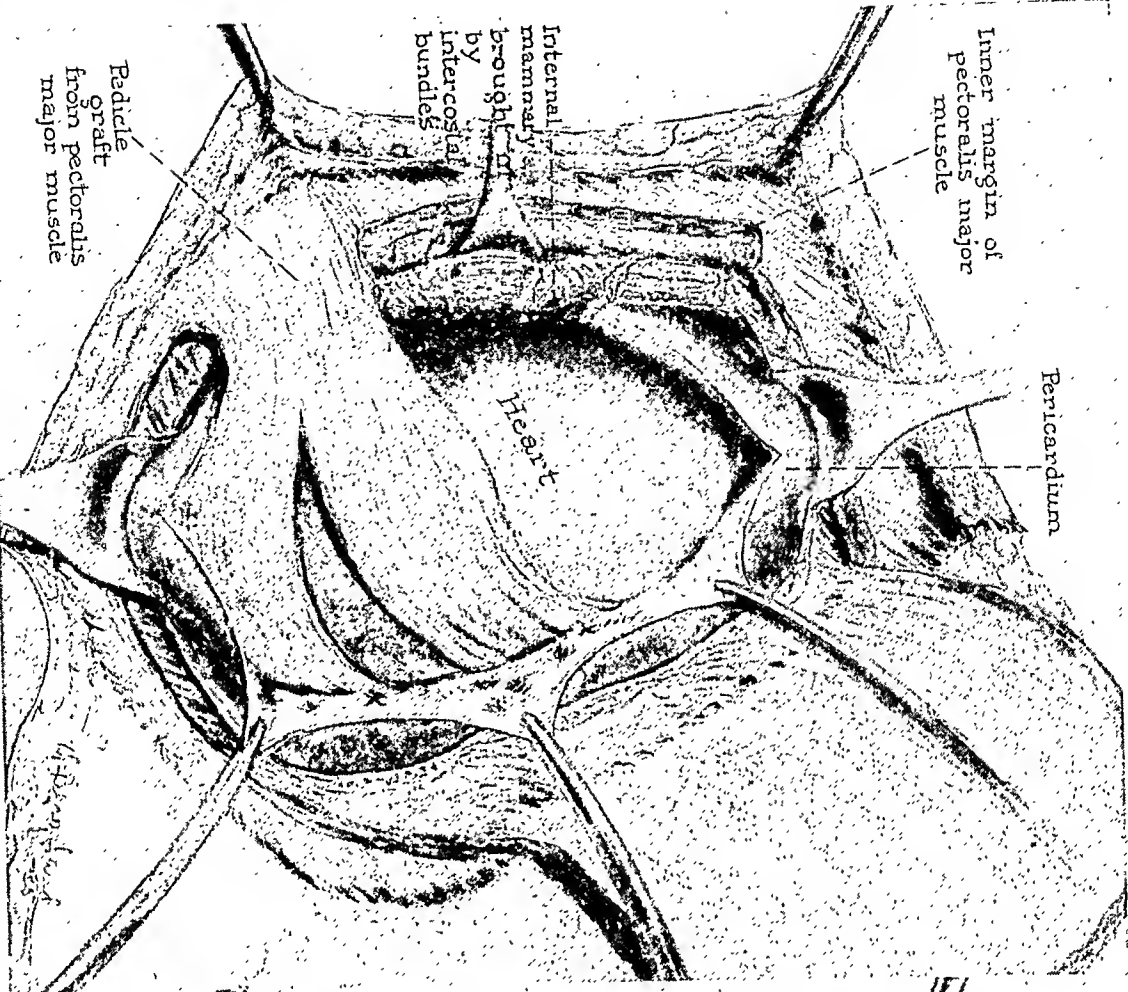


FIG. 4.—The pedicle grafts were carried posteriorly to the circumflex bed and sutured to the parietal pericardium. The intercostal bundles were carried beneath the sternum and sutured to the parietal pericardium. This carried the internal mammary vessels onto the surface of the heart.

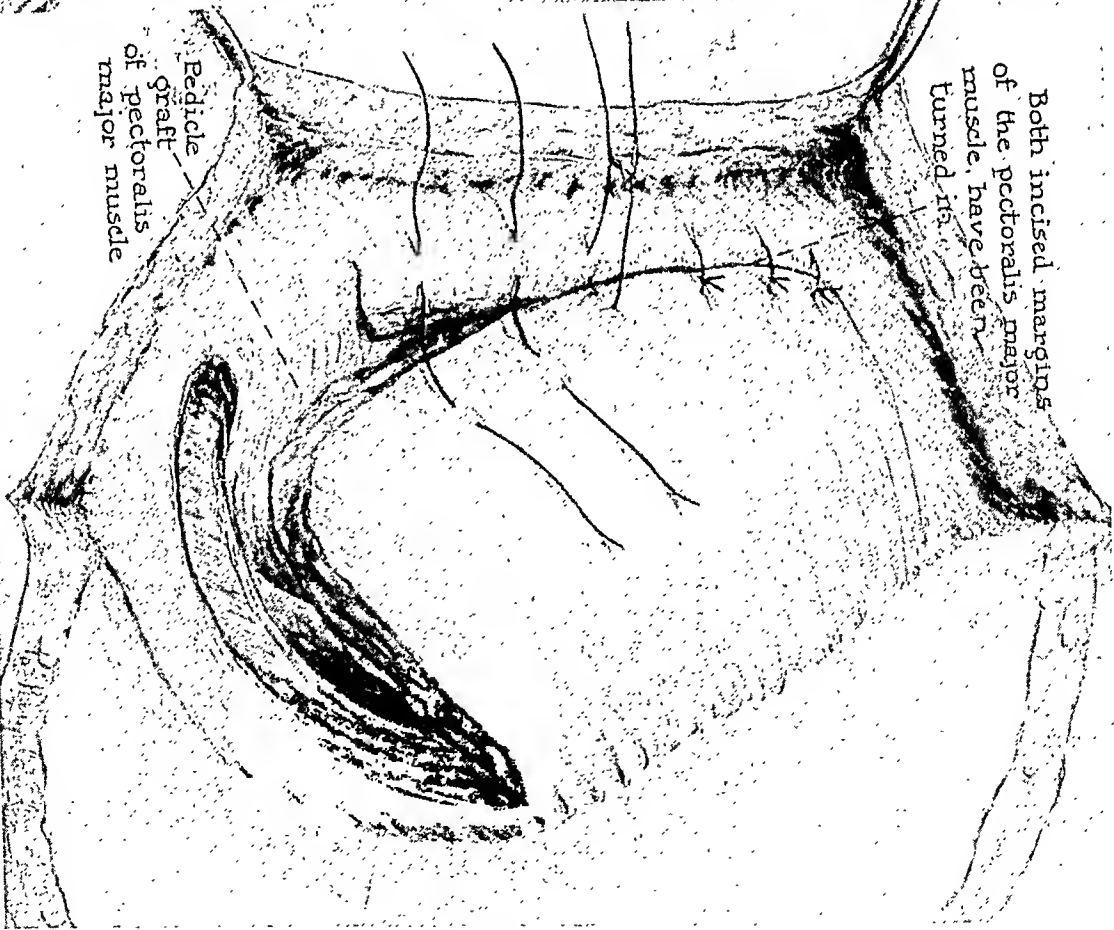


FIG. 5.—The parietal pericardium was left open and the incised margins of the pectoral muscles were inverted so that they came into contact with the heart.

he felt suffocated, was dyspneic and the heart palpitated. Epigastric distress after meals was also a prominent symptom. Numbness and tingling of the left hand and fingers frequently accompanied the pain. Ten days before admission to the hospital the patient, while carrying some wood into his house, was seized with violent, sharp, precordial pain, dyspnea and dizziness. He went to bed where he remained until he came to the hospital.

The patient was well developed, well nourished and of a phlegmatic temperament. His expression was worried. Examination of the precordium was negative. The heart was slightly enlarged to the left. On admission to the hospital the systolic pressure was 155 and the diastolic pressure was 95 Mm. Hg. The peripheral arteries were moderately thickened and tortuous. Exercise produced substernal oppression but no sharp pain. The electrocardiogram after exercise showed no significant change. While in the hospital the

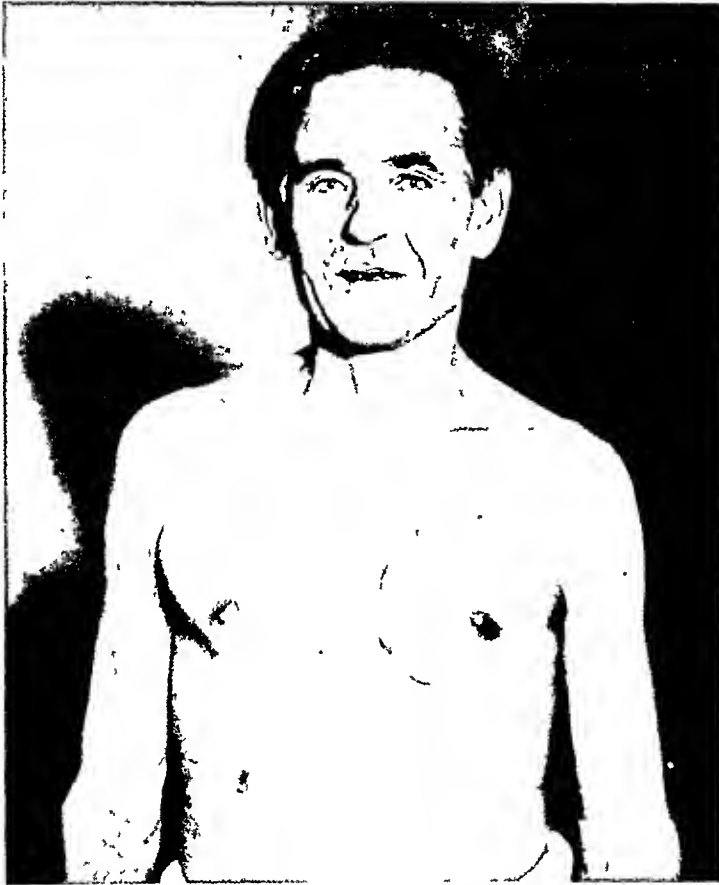


FIG. 6.—Patient three and one-half months after operation.

patient suffered a sudden, severe, knife-like attack of pain after taking a bath. The pain was precordial, to the left of the sternum, and did not radiate. At the same time he became cyanotic, very dyspneic and extremely apprehensive. Amyl nitrite gave him relief. A diagnosis of coronary sclerosis and angina pectoris was made. The electrocardiographic findings would indicate that there was no bundle damage thus far. He also had generalized arteriosclerosis and a mild degree of hypertension.

The patient consented to operation. He desired to go home to visit with his family but he returned to the hospital at midnight because of pain and a fear of impending death.

Operation.—February 13, 1935. Gas-oxygen anesthesia was used. The insertion of the left pectoral muscle was incised at the suggestion of Dr. W. C. McCally, for the purpose of mobilizing this muscle. This wound was closed. A curved incision was then made to the left of the sternum. (Fig. 2). The fascia was dissected from the left

pectoral muscle. The inferior portion of the pectoral muscle was incised for the purpose of making a pedicle graft. An incision was then made through the pectoral muscle parallel to the sternum exposing the third, fourth, and fifth costal cartilages. The muscle was freed from the chest wall. These cartilages were removed. The intercostal bundles were cut laterally leaving them attached to the region of the internal mammary vessels. The pericardium was incised from base to apex (Fig. 3). The lining of the pericardium everywhere was roughened by means of a burr. The epicardium was removed in shreds by means of a burr. This produced a great many extra systoles and some dilatation of the heart. Rest periods were given. At the suggestion of Doctor Wearn I tried to palpate the coronary vessels but with the heart moving I could not be sure that I could feel them. The pedicle graft was then divided longitudinally and both pedicles were swung around to the circumflex area of the heart. These grafts were sutured laterally and posteriorly to the parietal pericardium (Fig. 4). The intercostal bundles and the medial margin of the pectoral muscle were carried beneath the sternum and attached to the parietal pericardium. These structures carried the internal mammary artery onto the surface of the heart. The lateral margin of the pectoral muscle was then inverted so that the incised surfaces were in contact with the heart (Fig. 5). The fascia of the pectoral muscle was sutured; the skin was closed. The wound was not drained.

Three and one-half months have elapsed since the operation (Fig. 6). The patient has been kept in the hospital during this period but during the last six weeks he has been doing light work, such as serving trays, moving beds. *etc.* For several weeks after operation he had indigestion after meals. This has disappeared. He claims that he has no precordial pain; that the feeling of oppression over the heart has disappeared, that he has no sharp radiating pains to the shoulder and arm. He claims that he is well. He can exercise without pain, although up to the present time he has done no hard physical work. I have emphasized the importance of describing accurately what symptoms he has, but to me and to everyone else who talks with him he claims that he is better. Objectively I can say that he appears to be better. The worried expression has left him, and he has a fine spirit.

SUMMARY

The heart can be given a new blood supply experimentally. On the basis of this work a collateral vascular bed to the heart should offer some benefit to patients suffering from coronary sclerosis. A collateral vascular bed was given to a patient with coronary sclerosis on February 13, 1935. Three and one-half months after operation the patient claims that he has been greatly benefited. However, it will be necessary to have a number of such results before we can attach any clinical significance to this operation. I want to emphasize the point that the work is still in the experimental stage and I do not recommend the performance of this operation until it is established by operation upon a number of patients.

ADDENDUM: September, 1935. Seven months have now elapsed since the operation on the first patient. He continues to work as a gardener; he has no pain and he claims that he is cured. I have carried out the operation on five additional patients, making the total number seven. The third patient had an extremely marked degree of arteriosclerosis. At the operating table I could palpate the ramus descendens. It was hard, tortuous and several millimeters in diameter. The patient had been incapacitated since 1942. One and one-half years ago a total thyroidectomy was done. He has kept his basal metabolic rate at about minus 20 by taking thyroid extract. His life had been of a vegetative nature,

spending as he did 20 hours a day in bed. Two and one-half months have elapsed since we did the cardiac anastomosis. He states that he is completely free from all pain and discomfort. He is able to take twice the dose of thyroid extract that he took before the operation and his basal metabolic rate is plus 2. He is up and about six to eight hours a day and his interest in life has returned. He is still an invalid and he is still weak, but the complete absence of pain, his normal basal metabolic rate, his increased activities and interests, are facts that may be of real significance in establishing the operation as a beneficial procedure. The fourth patient is a well known surgeon from Ashland, Kentucky, who came to me because he believed in the soundness of my operation. He had suffered a myocardial infarct with dilatation and failure. He also had diabetes mellitus. He believes that he has shown some improvement but the pulse rate on occasions becomes rapid and he has had several attacks of anginal pain since operation. A sufficiently long interval has not elapsed to comment on the other cases. These cases will be reported by Dr. Harold Feil and myself.

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DISCUSSION.—DR. JOHN B. FLICK (Philadelphia, Pa.).—The experimental work of Claude Beck, in establishing a collateral vascular bed in the myocardium of animals and thus protecting the myocardium from anoxemia due to coronary occlusion, furnishes an entirely new avenue of approach in combating cardiac ischemia due to coronary artery disease in human beings.

Sir Thomas Lewis says, "The malady originally described by Heberden under the term angina pectoris is one in which pain of characteristic type occurs during effort. It is by far the commonest form of malady in which angina pain occurs. The pain may be interpreted as resulting when the blood supply to the heart, or part of the heart, is limited and consequently inadequate when the heart is called upon to do work at a certain increased rate—a condition of relative ischemia."

The operative treatment of angina pectoris first proposed by Francois Frank in 1899 and first practiced by Jonnesco in 1916 was purely symptomatic and was not intended to eradicate the disease. The surgical act aimed at division of the nervous arc thus preventing the patient from recognizing the symptom pain (Elliott C. Cutler). Since then various neurosurgical procedures along similar lines have been devised for the relief of cardiac

pain and practiced with more or less success, but they have not gained greatly in popularity, possibly because of technical difficulties and possibly because of the uncertainty of the results.

Removal of the normal thyroid gland in the treatment of heart disease was proposed by Blumgart, Lavine and Berlin and was practiced for the first time on December 14, 1932, at the Peter Bent Brigham Hospital in Boston. Strikingly beneficial results from this operation have since been obtained in the group of patients suffering from angina pectoris. The rationale of this procedure for the treatment of heart disease has its basis in the reduction of the metabolic demand on the heart by the total ablation of the thyroid gland.

Beck's operation strikes directly at the myocardial ischemia and theoretically should be beneficial where the ischemia is due to organic changes in the walls of the cardiac vessels. Experience alone can determine the place in surgery of Beck's ingenious and logical operation and he is to be congratulated upon a fine piece of work which at least has proved that a collateral circulation can be established experimentally in the myocardium of animals.

DR. ELLIOTT C. CUTLER (Boston, Mass.).—I should like to be among those who congratulate Doctor Beck upon what I know to be the end-result of a vast amount of work and a most ingenious investigation.

This morning our President spoke of our job as one of keeping Nature from taking us away before our time, but I wonder whether we should apply our energies to people as young as forty, as suggested by Doctor Cheever. I had the opportunity to see Doctor Beck's first patient as he was recovering from the operation and the ordeal did not seem unusual.

It is certain that the attack proposed by Doctor Beck and the physiologic background for this procedure are much more admirable, much better suited and far more certain to hold hope for ultimate good than any procedure yet proposed for those cardiac disorders that have as beginnings and cause ischemia of the myocardium.

Whether one is to turn in muscle flaps which many of us have tried in other conditions without much success, whether one is to use the fat about the pericardium, or whatever the actual method of establishing the collateral circulation is to be, it is certain that the understanding of what seems necessary and which Doctor Beck has attempted to carry out in these experiments constitute the most logical attempt that has ever been suggested.

The difficulty, of course, is going to be the same as we all have found in other conditions, now that ingenuity of the surgeon has brought us so far apace, *i.e.*, to convince our medical colleagues that our undertakings are desirable, or perhaps educate them to help us choose which case is desirable for the definite procedure.

Knowing how in this country surgery of the pericardium has lagged behind such surgery elsewhere, partly because of the attitude of our internists, one can imagine the difficulties in this field of choosing the proper case of arteriosclerotic heart disease, angina or hypertensive heart disease, as the one best suited for such procedure. I have no doubt if Doctor Beck keeps at it, and he fortunately has a group of medical colleagues who are interested and will help him, he will be able to tell us in a few years which form of heart disease is best suited and most likely to be relieved by this procedure.

I think we should all congratulate him sincerely for an admirable piece of work.

DR. W. F. RIENHOFF, JR. (Baltimore, Md.).—Independently and without any knowledge of Doctor Beck's experiments, or interest in this problem, we

began in October, 1934, investigating different methods of supporting an interrupted coronary circulation. We have used a series of old dogs for the reason that the independent development of a collateral circulation in younger animals is so readily achieved that recovery from ligation of the right or left anterior descending coronary artery may be clinically uneventful and easily survived by the animal. Doctor Beck did not state whether his series of dogs were young or old. In the older dogs, in our experience, ligation of the left anterior descending branch of the left coronary artery almost always resulted in either ventricular fibrillation or a marked arrhythmia. Ligation of the left coronary artery before departure of the circumflex resulted invariably in ventricular fibrillation. In a small series of nine dogs, Dr. E. Cowles Andrus, Dr. August Jonas and myself obtained electrocardiographic studies before beginning the experiment, and used only those animals in whom the electrocardiograms were normal. Under ether anesthesia, an incision was made in the fifth interspace on the left side exposing the pericardial sac which latter was opened. The central tendon of the diaphragm was then incised and the omentum drawn up into the left thoracic cavity. The epicardium was then moistened with half strength iodine and the omentum wrapped, so to speak, completely about the heart, entirely covering the anterior surface. To insure maintaining this position the omentum was fastened to the epicardium by two interrupted fine silk sutures. The pericardial sac was not closed but the hiatus in the central tendon of the diaphragm was pulled snug about the omentum. After this cardio-omentopexy had been performed, Doctor Andrus found the type of electrocardiographic curve present, suggested a coronary occlusion. Whether this alteration in the electrical reaction of the dog's heart was due to the small amount of iodine painted on the epicardium or whether it was due to the two stitches placed in the heart wall, away from the coronary vessels, was not determined. Three to six weeks later, ligation of the entire left coronary artery just below its origin from the aorta and above the division into the left anterior descending and circumflex arteries was accomplished by taking a deep bite with a French No. 2 needle in the ventricular wall in the region of the left coronary artery just beneath the tip of the left auricle. The distension of the coronary veins distal to the ligature proved its location. No disturbance in cardiac rhythm followed these ligations after previously performed cardio-omentopexy, either clinically or in the electrocardiogram. The dogs were not at all ill and were up and around their cages the next day. Whereas before similar ligation was invariably fatal, not one animal succumbed after adhesion of the omentum to the heart had been produced. At the second operation extensive adhesions were revealed to have occurred between the omentum and the heart wall. These bled profusely when slightly separated. The electrocardiograph remained the same following the first and second operative procedures. In other words, ligation of the entire left coronary vessel in this series of old dogs was relatively inconsequential when the coronary circulation was properly supported by an outside source of blood supply. We are in the process of sacrificing and injecting our specimens. Carmine gelatin was used for the coronary circulation, being injected in the aorta. This solution will not go beyond the arterioles and thus will not fill the capillary bed in the myocardium. No injection mass entered the cavities of the heart and therefore the thebesian vessels were not injected. Prussian blue mass was injected into the celiac axis, thus filling the omental vessels. This mass will fill the capillary bed and in the as yet incompletely cleared specimens, seems to have penetrated the capillary branches of the coronary system.

These specimens will be reported on later. We have not entertained the hope that this procedure of cardio-omentopexy will be clinically applicable except possibly in such cases of coronary thrombosis that might be seen at an early stage of the interruption of the coronary circulation.

DR. J. SHELTON HORSLEY (Richmond, Va.).—Is there not some difference between the circulation of the blood from the omentum and that from the pectoral muscle? According to the procedure described by Doctor Beck the pectoral muscles were severed near their insertion, and a portion of the muscle turned onto the heart. This would, of course, involve destroying the nerve supply to the pectoral muscles, with consequent atrophy of the muscle and diminution of its blood supply, even if no vessels had been actually injured when the muscle was divided. The omentum, however, when brought up to the heart would suffer no trophic changes, and consequently circulation would not be impaired by such conditions as beset the pectoral muscles when they are divided near their insertion.

DOCTOR BECK.—The second patient upon whom we carried out our operation died one week later. A thrombus developed at the bifurcation of the aorta and occluded the left common iliac artery. The ischemia of the leg was very painful and the patient died within several hours. The thrombus developed at the site of an atheromatous ulcer of the abdominal aorta. The coronary arteries showed extensive and marked sclerosis. The right coronary artery was completely occluded about 14 Mm. from its ostium. The lumina of the ramus descendens and of the ramus circumflexus of the left coronary artery were markedly constricted but not completely occluded. The myocardium of the right ventricle showed extensive replacement by fat. There was no evidence of infarction in the left ventricle. The pedicle grafts of skeletal muscle and the adjacent fat and pericardium were adherent to the myocardium and for the present at least I am satisfied with this part of the operation.

In our experience ligation of the ramus circumflexus of the left coronary artery in one stage had a high mortality, even though a collateral vascular bed had been provided for the heart. Ligation in two stages is usually successful. This statement applies to the right and to either major branch of the left coronary artery.

The pedicle grafts of skeletal muscle brought in from the chest wall are deprived of some of their normal blood supply. We know, however, that the body has a great capacity to develop blood vessels and in our experiments we obtained excellent anastomoses between the vessels of cardiac muscle and of skeletal muscle. We used omentum in a number of experiments. Anastomoses between the coronary bed and the vessels of the omentum can be obtained. I am doubtful whether omentum could be used on a human patient because the opening in the diaphragm complicates the operative procedure. Experience may alter this point of view.

TRAUMATIC CARCINOMA OF THE BREAST

EMMET RIXFORD, M.D.

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WHEN statistics of carcinoma of the breast in which trauma is alleged to be the cause, vary from 6.8 per cent (Rosenstein) and 7.3 per cent (Guleke) to 37.9 per cent (Sprengel) and 44.6 per cent (Williams), it is evident that the value of these statistics as proving or disproving the traumatic origin of breast cancer is very small. Even statistics on relatively large numbers, by which it might be hoped to eliminate other factors, show similar if smaller variation. Ziegler, in 170 cases, found 37, or 22 per cent, to be due to alleged trauma. Loewenthal, in 934 cases found 135 or 13.4 per cent and H. Snow, in 9,600 cases of carcinoma of the breast found 11.5 per cent to have a supposedly traumatic cause. These figures average a little less than 12 per cent.

It is very unusual for a person not to be able to recall some more or less remote injury to the breast in which carcinoma has been found, such as striking it against the edge of a bedroom door in the dark, slipping in the bathtub or on a rug, the breast striking a chair or other piece of furniture, perhaps more frequent than all, a blow by someone's elbow in a jostling crowd or a vicious kick by a child carried in the arms. Often in such cases the carcinoma is discovered when patient goes to the doctor because of the bruise, and the doctor finds the tumor too large to have grown in the interval following the trauma, the injury serving merely as the occasion of the discovery of the carcinoma.

For these and other reasons, pathologists and clinicians are skeptical of the allegation that trauma may cause carcinoma in a normal breast. Perhaps the case is a little better for chronic or repeated traumata than for a single blow.

Manifestly, from the nature of the case, it is impossible to prove the proposition, but what can be done, and it would seem to be worth while, is by collecting a sufficiently large series of presumptive cases which, verified as to the nature, severity and date of the trauma, date of discovery of the carcinoma, histologic character of the growth, *etc.*, to arrive at a fair estimate of the probabilities in the premises.

There is real need for such an authoritative statement of probabilities for use in legal decisions, particularly in industrial accident and workmen's compensation relations.

Various criteria have been put forward in this connection, but it is difficult to satisfy all of them.

1. A definite injury of considerable severity.
2. Development of tumor at the injured spot.
3. In the case of the breast, a tumor which histologically is of a known form of breast tumor.

4. Tumor discovered three weeks or more after the accident (German practice), and then should not be larger than likely to have grown in the interval following accident.

5. Absence of tumor at the site of injury before the accident. This last would be of great value in the determination, but may not be regarded as a *sine qua non*, for only rarely would a person be examined, even for life insurance, with sufficient thoroughness.

The case herewith reported fulfils all the above conditions except the last. It is published for its value as a case of carcinoma of the breast presumably caused by a single blow on the gland.

This case has been given an unusual amount of study, and while there are several hiatuses in the record, the conclusion is all but irresistible that the trauma was the probable cause of the subsequent carcinoma. Moreover, the case presents a number of unusual conditions, themselves worthy of record.

CASE REPORT

E. S., just under 17 years of age, was commandeered with others in his town to fight a forest fire. On September 22, 1928, running down hill to avoid the fire, he stumbled and fell down a bluff, striking his right breast violently on a tree stump, one and one-half or two feet high. The breast became swollen at once but when pain and soreness persisted, the boy feared that he had broken a rib, and only on the seventh day first consulted a physician, who "found the breast swollen to the size of half a grapefruit, red, hard and discolored, the skin over the upper central part of the breast abraded, the areola and nipple also injured. Temperature 101°. Nodes in both axillae somewhat enlarged, presumably from the abraded areas being infected. Roentgenography showed no fracture of rib. Under ultraviolet irradiation and hot applications the swelling gradually went down, and as the abrasions healed, the axillary swelling disappeared. In a few weeks the breast became normal except for a knot, the size of a chestnut, directly under the nipple which would not absorb." The patient was discharged as ready to return to work on November 16, 1928, nearly eight weeks after the accident.

On November 25 he again consulted his physician because the swelling was growing, and by February 1, 1929, it was "as large as half a lemon, being conical with diameter at the base of almost two inches causing dimpling of the skin when moved." It was also slightly tender. The doctor, fearing it was carcinoma, sent patient to a surgeon, who described the growth as of "about the size of a silver dollar, hard, leathery, about one-quarter inch thick, of very firm consistency, its center a little above the nipple. The skin is freely movable over the mass and it is freely movable over the pectoral muscle." He considered it potentially malignant, and advised its removal.

On March 5 the surgeon removed the entire breast subcutaneously through an incision around the lateral inferior border, but did not investigate the axilla. He looked at the growth after removal, found it yellowish in color; said it had no resemblance to carcinoma even on section; that it was "just a fibrous mass, the result of mastitis, as he had removed from the male breast in a number of instances," and threw the tissue away!

Two and one-half years later (November 25, 1931) he was again consulted because of the appearance of a painful lump in the opposite (left) axilla. Axillary nodes the size of pigeon eggs, some also at base of neck. Blood examination: Red cells 5,000,000; leukocytes 9,200, 65 per cent polymorphonuclears. No injury nor abrasion of hands; patient did clean some rabbits in November—no sign of general infection.

An axillary node was excised (February, 1932) and examined by the late Dr. W. Ophüls, pathologist of Stanford Medical School, who pronounced it metastatic carcinoma.

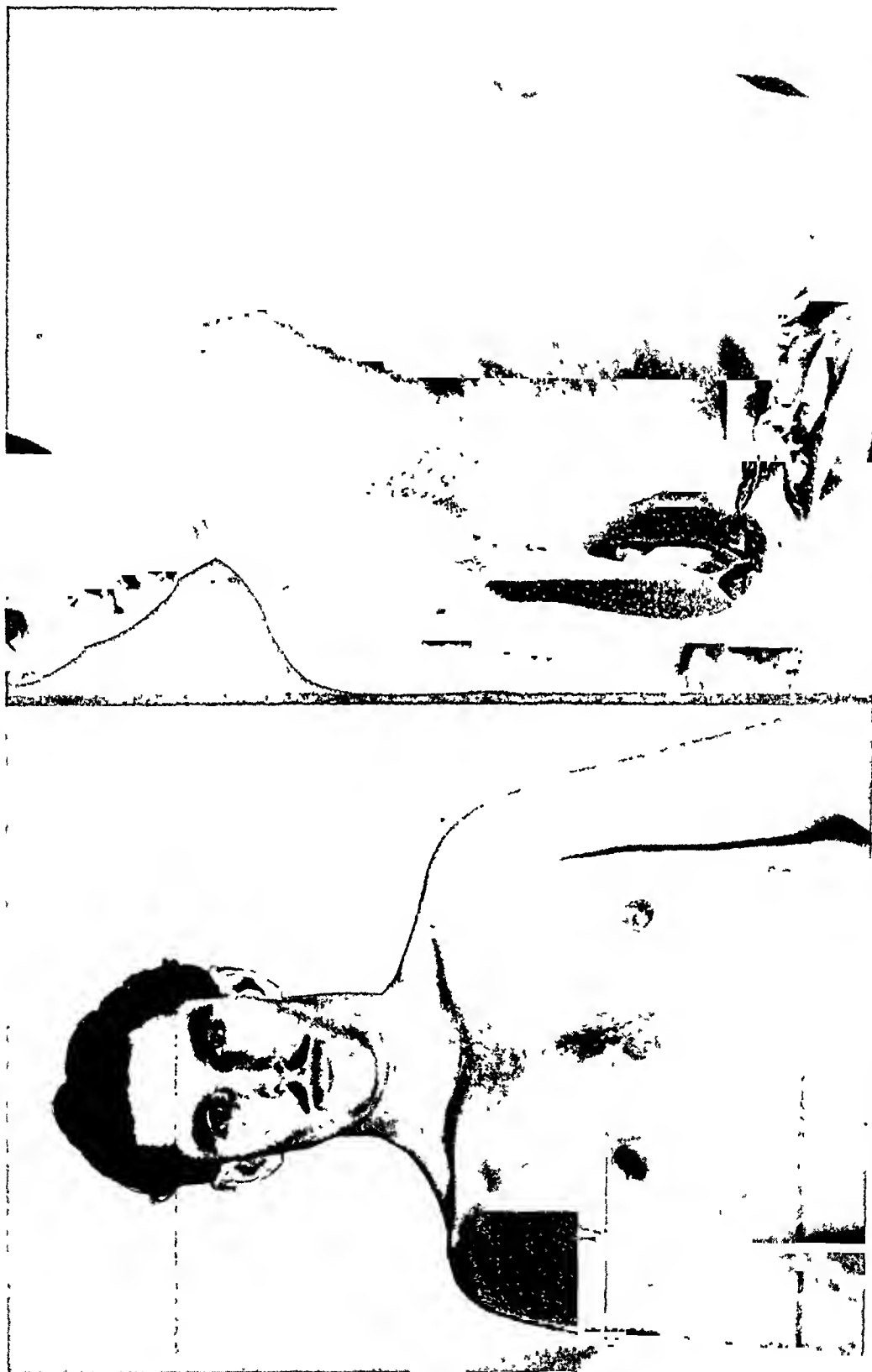


FIG 1.—Left side of neck, left arm and the entire trunk edematous.

FIG. 2.—The skin of the trunk, more so on the left side, was filled with myriads of small tumors visible only by tangential illumination.

Claim was made by the patient and his family against the State Compensation Insurance Fund and the matter brought before the Industrial Accident Commission of California. The record was examined by a number of surgeons on behalf of the Commission with varying opinions as to the industrial nature of the carcinoma. The patient, doing badly, was brought to San Francisco and put under my care on August 17, 1932. He then complained of shortness of breath but felt encouraged because he was gaining in weight.

On examination patient was seen to be a tall, well built young man of 20, pale and in evident distress. Left side of his neck, left arm and the entire trunk edematous (Fig. 1). Both sides of the chest dull, moderate ascites, hence the gain in weight. The skin of the trunk, more so on the left side, was filled with myriads of small tumors, palpable but visible only by tangential illumination (Fig. 2). Temperature 99°; pulse 96; respiration 24. Wassermann negative. Red cells 5,545,000, reticulocytes 9.9 per cent; hemoglobin 100 (Sahli), leukocytes 13,150, of which 86 per cent were polymorphonuclears, 17 per cent banded, 69 per cent segmented; platelets 229,395.

Roentgenologic examination of the chest showed pleural effusion and pericardial distension, but no bony metastases. Biopsy of one of the skin nodules showed carcinoma, its cells filling the lymph spaces of the skin.

The dyspnea rapidly increased in the next day or two. On August 24 1500 cc. of clear fluid was removed from left chest, with but little improvement in the respiration. Two days later when preparations were being made to aspirate the pericardium, patient suddenly died.

Autopsy by Dr. J. B. McNaught, assistant pathologist, Stanford Medical School, showed the immediate cause of death to be an hemopericardium, the blood having evidently come from a slow oozing pericardial metastasis. Fluid in both pleural cavities; metastases in the lymph nodes of each axilla, on the right with necrotic centers, therefore presumably older than on the left. Metastases numerous in the mesenteric and mediastinal lymphatics, but almost none in the liver, spleen, lungs, heart and kidney. There were lymphatic metastases in the tissues about the prostate but no tumor found in the gland itself.

A remarkable feature of the case was the widespread occurrence of metastases in the lymphatic system, particularly in the skin of the trunk, in fact everywhere except in the skin and subcutaneous tissues of the right breast, the site of the surgical operation.

Most meticulous search by the pathologist failed to find any tumor which could be considered primary. Histologically, the tumors all over the body were identical and consisted of large epithelial cells, sometimes arranged in gland-like order, the arrangement being such as to suggest origin in the breast and in no wise resembling intestinal glands.

It seemed to me highly probable that the case was a result of the injury to the right breast three years before, and I so reported to the Industrial Accident Commission, accounting for the failure of the tumor to appear in the skin of the right breast by the fact of the operation having blocked the lymphatics. The wide dissemination of the lenticular metastases in the lymph spaces of the skin (Fig. 2) is sufficient answer to the claim made in defense that cancer of the breast is not likely to appear in the lymph nodes of the opposite side. It also seemed probable that the inflammation which followed the abrasions perhaps also the hematoma which resulted from the injury contributed to the blocking of the lymph channels through the right axilla, but since the lymphatics of the opposite axilla were also blocked, it may be that the size of the

cancer cells was the chief circumstance which prevented the carcinomatous elements being poured into the blood stream. It was certainly remarkable that the tumor appeared not to have been disseminated through the blood stream but almost exclusively through the lymph spaces and lymphatic vessels.

The responsibility of the decision was such that I asked that the record and sections be submitted to Dr. James Ewing of New York. After much study in his laboratory, and debate, Doctor Ewing replied as follows: "This case has been extensively discussed by our staff, and we feel that there is no escaping from the conclusion, that in all probability, if not with reasonable certainty, this boy presents a genuine case of traumatic mammary cancer. The lack of sections of the original tumor, and of knowledge of the previous condition of the breast, can hardly balance the very striking evidence of the traumatic origin, indicated by the very clear clinical history. It is a most remarkable case, and it should be recorded."

The record and correspondence being reported to the Industrial Accident Commission, they decided in favor of the family.

SURGICAL SIGNIFICANCE OF ENDOMETRIOSIS

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ENDOMETRIOMA is one of the many names at present applied to tumors containing endometrium or tissue resembling endometrium, and which respond to the same stimuli as those which affect normally situated endometrium. These tumors are recognized much more frequently now than formerly. There is no doubt that many of them cause grave symptoms, necessitating extensive operations.

The etiology of endometriosis, or adenomyosis, has been the subject of much discussion by gynecologists and pathologists, and the probability is, as Ewing has suggested, that similar tumors, included at present under the same name by various authors, have entirely different origins. The various theories as to the origin of these interesting tumors are as follows: (1) They develop in adult life from embryonic rests from Müllerian ducts or the wolffian body. (2) They are diverticula of endometrium, invading the uterine wall or adherent structures. (3) They develop by metastasis through the blood or lymph stream. (4) Metaplasia of the serosal endothelium, into tissue resembling endometrium, takes place as the result of inflammatory reaction. (5) Any of the tissues that have the coelom as a common anlage may revert into tissue resembling endometrium as the result of hormonal influences. (6) Living endometrial tissue is implanted on pelvic peritoneum and the ovaries, as the result of retrograde menstruation through the fallopian tubes. Advancement of this last view, by Sampson, and his suggestion of the name "endometriosis," have been the cause of much discussion and of many papers on the subject by leading gynecologists throughout the civilized world.

It is not my purpose to go into an evaluation of the relative merits of the various theories. However, one point against the theory of reflux of menstrual products, that never has been mentioned, so far as I know, in the extensive literature on the subject, is the fact that instead of the tubes being open, as has been contended by Sampson,⁴ it would be expected that they would be closed as the result of adhesions caused by the chemical irritation of the menstrual blood. It is known that in cases of complete obstruction of the uterine cervix, the menstrual fluid accumulates first in the uterine body and then the tubes become dilated. The first blood which comes through the fimbriated end apparently causes dense adhesions at that point. In such cases, gross accumulation of blood is never seen in the culdesac, nor is evidence found that any considerable quantity of blood has ever been there. Instead, a huge hematosalpinx is often found.

Diagnosis.—At present, a preoperative diagnosis of adenomyoma, ectopic

adenomyoma, endometrioma or endometriosis is frequently made. The symptoms, however, vary so much that it is not possible to be correct in a very high percentage of cases. The factors that, if present, will help most in making a correct diagnosis are: (1) a patient's age of between 25 and 45 years; (2) dysmenorrhea of the acquired type; (3) pelvic discomfort, often extending to the sacrum, into the rectum, or down the thighs, always worse at the time of menstruation; (4) menorrhagia; (5) sterility which may be absolute but more often is relative; and (6) dyspareunia. The findings on bimanual pelvic examination vary with any associated pathologic condition that may be present, and with the extent and situation of the disease. A frequent finding is

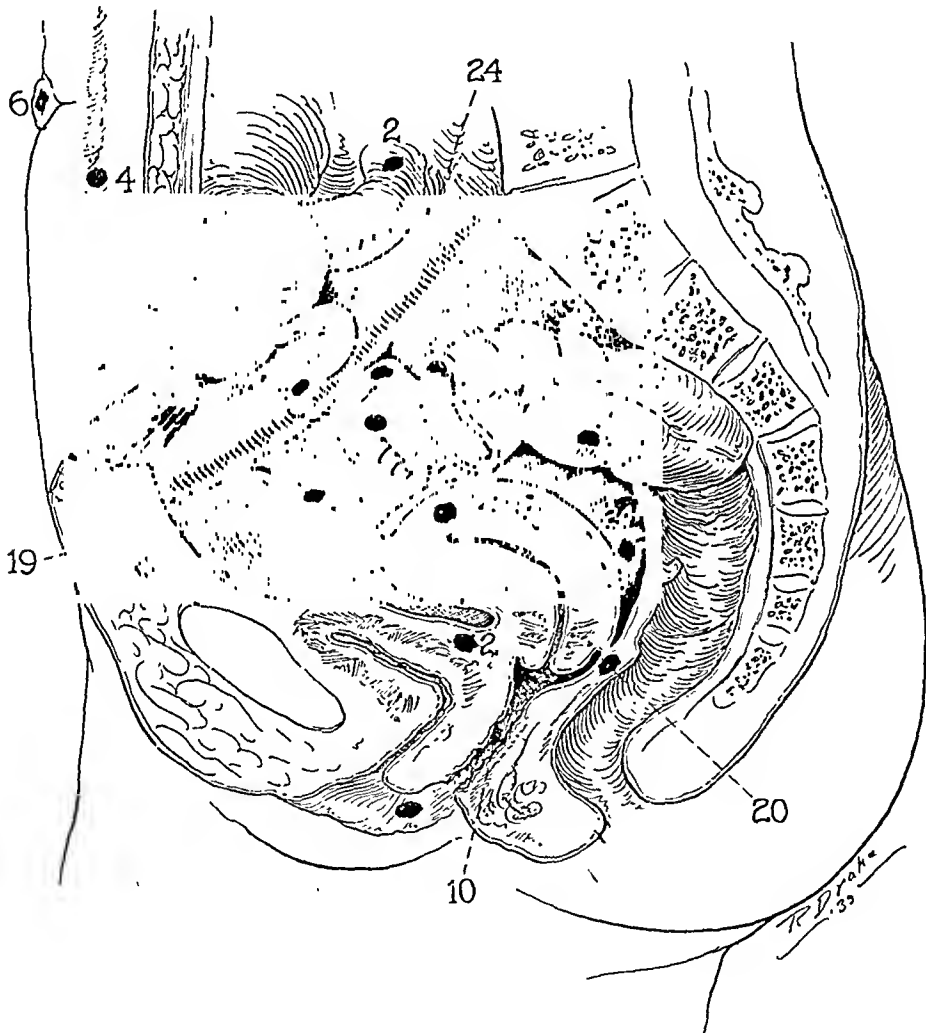


FIG. 1.—Showing situations where adenomyomas have been reported.

adhesions, causing fixed retroversion of the uterus, with or without recognizable tumor; also, thickening in the adnexal regions and tenderness on pressure. In some cases cysts several centimeters in diameter develop in the ovaries. Small, irregular nodules or thickenings of the rectovaginal septum, or in the culdesac, best felt on rectal examination, are highly suggestive.

Incidence.—The incidence of endometriosis is hard to determine, for many

of the tumors are small and are not recognized by many surgeons or pathologists in routine examination of removed tissue.

Situations where heterotopic endometrium or tissue resembling endometrium have been reported to have been found (Fig. 1) are as follows: (1) in the uterus, where the growths may be diffuse or discrete and (2) outside the uterus, where they may be in the ovaries, rectovaginal septum, uterine ligaments, fallopian tubes, abdominal wall, umbilicus, groin, intestinal wall, wall of the bladder, or the vagina (Table I).

TABLE I

Situations of Adenomyomas That Formed the Bases of This Study: Operations Performed in The Mayo Clinic, 1923-1934, Inclusive

Organ*	Number
Uterus	482
Ovary (probably not complete)	77
Rectovaginal septum	20
Ligaments of uterus	19
Sigmoid	14
Pelvic peritoneum	24
Ileum	2
Umbilicus	6
Fallopian tube	22
Vaginal wall	10
Appendix	1
Bladder	2
Abdominal wall	10
<hr/>	
Total organs	689
Total patients	576

* More than one organ may be affected. Therefore, the total does not add to 100 per. cent.

DIFFUSE ADENOMYOSIS

Relatively frequently, diffuse adenomyosis is found in uteri removed from women who soon will reach the menopause. Many of these patients give histories of having a severe, acquired type of dysmenorrhea, menorrhagia, and sterility of several years' duration; previous to that time they may have borne two or more children. The uterus may be three or four times normal size, and regular in outline unless fibromyomas also are present. If the adenomyomas are not removed before the menopause, they undergo atrophy at that time and, as a rule, cause no symptoms. However, the possibility of malignant change taking place in any endometrium or in tissue resembling endometrium must be kept in mind. Malignancy of the body of the uterus is often suspected in these cases, and it can be ruled out only by diagnostic dilatation and curettage and examination of the tissue by a competent pathologist. There is no doubt that the gross appearance of the mucous membrane removed in some of these cases suggests carcinoma of the body of the uterus. Carcinoma and adenomyosis may both be present in the uterine body, inde-

pendent of one another, and fibroid tumors and adenomyosis are rather frequently found associated in the same uterus.

From 1923 to 1934, inclusive, 4,751 uteri were removed from myoma in The Mayo Clinic. Of this number 482, or 10.1 per cent, were found to contain adenomyomas. This incidence is higher than the 5.7 per cent which Cullen¹ found in his series in 1908, or in the series reported by MacCarty and Blackman³ in 1918, in which the incidence was 6.43 per cent. In The Mayo Clinic series of 482 cases of adenomyoma of the uterus, it is interesting to note that malignancy was present in 14 cases and that in 280 cases, or 48.8 per cent, some pelvic operation previously had been performed.

Hysterectomy is often advisable in cases of diffuse adenomyosis of the uterus, and because most of the patients are at the age of menopause, or close to it, I believe both ovaries should also be removed. If women are less than 42 years of age, however, and there is no evidence of ectopic adenomyoma, it is advisable to save some ovarian tissue. Radium is being used, I think, too often in these cases, and with rather unsatisfactory results. Cure of symptoms, the most important of which is menorrhagia, will be obtained only if a castrating dose is used, and what is considered a sufficient dose in most cases is often insufficient in cases of marked uterine adenomyosis, probably on account of the thickness of the uterine wall. The beneficial effect, when obtained, is the result of the action on the ovaries, it is not the result of action locally on the growth.

DISCRETE ADENOMYOSIS

"Discrete adenomyosis" is the name applied to a condition in which small circumscribed tumors appear in the uterine wall. This condition is encountered less frequently than is the diffuse form of adenomyosis. The tumors suggest fibromyomas on palpation, but are not encapsulated and have to be cut away from the uterine wall in which they are growing. Their intimate connection with the uterus often suggests a malignant condition. They frequently cause no symptoms. In other cases they cause severe dysmenorrhea and menorrhagia especially if they extend into the cavity of the uterus. They are relatively frequently found in the cornua of the uterus or in the uterine terminations of the fallopian tubes. They do not respond well to radiotherapy, and surgical removal is frequently advisable. Among younger women, myomectomy is advisable but among women who are close to the menopause hysterectomy is justifiable, especially if the tumors are large.

ADENOMYOMAS OF THE ABDOMINAL WALL

Postoperative adenomyomas or endometrial transplants into the abdominal wall are occasionally seen following operations which expose the interior of the uterus. They are seen also sometimes following operations in which the uterus and tubes are not involved. According to Hertzler² they occur in about 1 or 2 per cent of cases in which the endometrium has been exposed. In some cases a fistulous tract leads to the uterus. In other cases, a com-

munication with the uterus cannot be demonstrated. The tumor in the abdominal wall, as a rule, appears in a few weeks after the operation but in some cases several years pass before anything abnormal is noted. In some cases the tumors will become larger and painful at each menstrual period and in occasional cases the skin will break over a bluish cystic mass and a small amount of dark fluid will escape. At The Mayo Clinic we have operated in ten cases in the last 11 years. Complete removal of all the adenomyomatous tissue is all that is necessary to effect cure.

ENDOMETRIAL TUMORS OF THE RECTOVAGINAL SEPTUM

Tumors of the rectovaginal septum are the most difficult to treat satisfactorily. As a rule, they cause considerable pain, especially at defecation and at the menses. As a result, they come under observation when they are in an early stage. If neglected, they may grow to considerable size, invading the rectal wall sufficiently to cause obstruction, and occasionally they may ulcerate through the mucosa of the bowel. In other cases, and these are more frequent, the tumors invade the vagina, and a blue-domed cyst, or a polypoid mass of uterine mucosa, may be noted in the posterior fornix; this mass bleeds at the time of menstruation. In still other cases the tumors will grow into the bases of the broad ligaments, may obstruct the ureters, or may cause severe back pain that extends down the legs as the result of pressure on the nerves. If these tumors are seen early, frequently they can be removed by vagina, but if the tumor involves the intestinal wall, resection of part of the anterior rectal wall, hysterectomy, and amputation of the vault of the vagina may be necessary to effect removal. This is seldom justifiable now, even if patients are young. A much simpler and safer procedure is to remove the ovaries or to effect complete castration by radium or roentgen rays. Local treatment of the growth is not necessary. The tumors readily can be distinguished from malignant growths because only in neglected cases of endometrial tumor of the rectovaginal septum is the mucous membrane of the bowel involved. Moreover, differential diagnosis can be made by microscopic examination of tissue. From 1923 to 1934, inclusive, 20 of these tumors were found at The Mayo Clinic.

INVOLVEMENT OF OTHER STRUCTURES

Many of the endometrial growths on the external surface of the fallopian tubes, uterus, uterine ligaments, ovaries, bowel (Fig. 2), and in the culdesac, are small, reddish-brown or purple lesions which bring to mind Sampson's implantation theory, for they are attached only to the peritoneum.

The Ovaries.—Besides the small lesions just mentioned, referred to as implants, cysts several centimeters in diameter are frequently found in the ovary, and from their appearance and situation suggest that they may have started deep in the ovarian tissue. The older and larger cysts are, as a rule, almost black, and cysts of more recent development, containing less blood, are lighter in color. The content of the cysts is apparently irritative to the peritoneum,

for dense adhesions always are found walling them in if they have ruptured previous to operation. It is practically impossible to remove such adherent cysts without rupturing them.

All hemorrhagic cysts of the ovaries are not Sampson cysts, or endometrial in origin, but gynecologists who are especially interested in this subject report finding endometrial tissue in many of them.

Although conservative operations are advisable in these cases, secondary

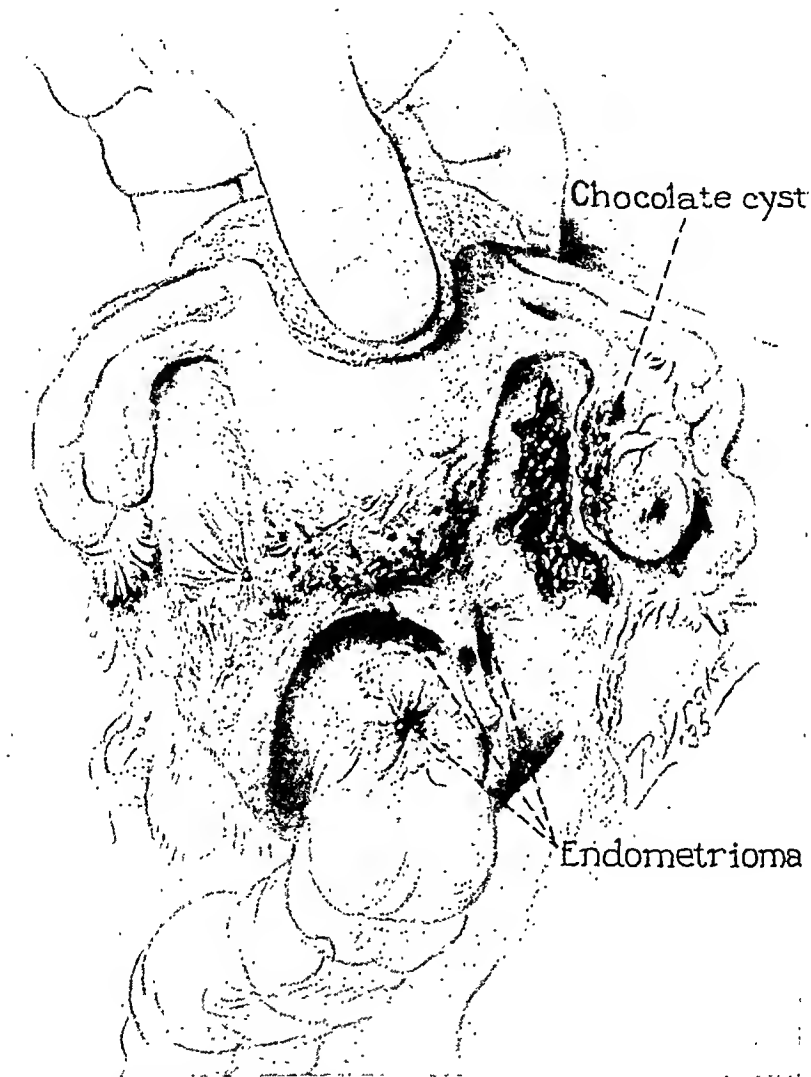


FIG. 2.—Multiple endometrial transplants with endometrioma or adenomyoma in the sigmoidal wall. Small chocolate cysts in the right ovary.

operations are frequently necessary when any ovarian tissue is saved. If it is advisable to remove all ovarian tissue, I believe the uterus should also be removed. The use of roentgen rays and radium is never indicated in these cases. Complications as the result of adhesions make it advisable to remove the pathologic tissues in all these cases. I do not want it inferred that both ovaries should be removed in all cases of hemorrhagic ovarian cyst, but in occasional cases in which there are multiple endometrial implants throughout the pelvis, especially if the rectovaginal septum or bowel is involved, radical

operation is indicated irrespective of the patient's age. Fortunately, most patients who have extensive trouble of this kind involving both ovaries and implants at various other points in the pelvis are very close to the menopause.

The Bowel.—It sometimes happens that growths resembling endometrium develop in the intestinal wall. They are most likely to be confused with malignancy or diverticulitis. In the roentgenogram there will be a filling defect, but there will be nothing distinctive, except in a case of diverticulitis in which multiple diverticula may be visualized at other points in the bowel. If a proctoscope can be inserted up to the region of involvement, change in the mucous membrane will be seen, with ulceration in cases of malignancy, whereas in adenomyoma and diverticulitis there will be no such change. As a further help in diagnosis, adenomyomas are most likely to be found only among women who are between 25 and 45 years of age, whereas diverticulitis and malignant growths are found most often among elderly men. In cases of adenomyoma involving the sigmoid, the patients complain of dull abdominal pain, as a rule associated with constipation which has been progressive over several months or even two or three years. The symptoms are most marked at the time of menstruation and attempts at defecation at this time often bring on rectal spasm. Cachexia is not a symptom in these cases.

On exploring the involved bowel, the external appearance in many cases suggests malignancy, but if adenomyomatous tissue is present at the point of adhesions, or on the surface of the bowel, a definite diagnosis can be made. We now know that adenomyomas undergo atrophy, and seldom give rise to any symptoms after cessation of ovarian function, and the simplest and safest way to treat any of these troublesome tumors is to remove all ovarian tissue. If obstruction exists, or is likely to become complete, temporary colostomy, as a preliminary operation, often is a life-saving measure. Seventeen cases in which there has been definite involvement of the intestinal wall (14 of the sigmoid, two of the ileum, and one of the appendix) have been seen in The Mayo Clinic in the past 11 years.

The Bladder.—The symptoms of an adenomyoma involving the bladder are vesical irritability, increased frequency of urination most marked at the time of menstruation, and hematuria; the blood in the urine may be only microscopic in amount, and blood may be present only during menses. If the tumor involves the base of the bladder, and if one or both ureters are obstructed, renal symptoms are added to the dysuria and hematuria.

On cystoscopic examination the picture naturally will vary with the extent of the lesion, and if tissue resembling endometrium is protruding, polyp-like, into the cavity of the bladder, malignancy will be suspected unless tissue is obtained for diagnosis. At an earlier stage bluish cysts will be visible through the thinned-out vesical mucosa. The bladder wall was involved in two cases in this series.

Treatment naturally varies with the extent and situation of the disease, and also with the age of the patient. Excision is advisable in all cases in which patients constitute good surgical risks, and when it is possible to remove the

tumor without traumatizing the ureters. In the latter type of case, removal of all ovarian tissue will cause rapid atrophy of the tumor. A similar result can be obtained by irradiation sufficient to cause castration. Two cases of adenomyomas of the bladder have been seen at The Mayo Clinic in the last eleven years.

The Umbilicus.—A true umbilical adenomyoma becomes larger and more painful at the time of menstruation, and frequently discharges a small amount of dark bloody fluid at that time. It is difficult to explain the genesis of this type of tumor in the region of the umbilicus except as metaplasia of the peritoneum. Surgical removal of the tumor and the umbilicus, and an overlapping type of closure, are advisable in all cases. In the last 11 years, six patients who had adenomyoma of the umbilicus have been operated on at The Mayo Clinic.

SUMMARY AND CONCLUSIONS

The genesis of adenomyoma is still an unsettled question. Probably some tumors containing tissues resembling the endometrium are in no way related to the Müllerian ducts.

Adenomyomas are of special interest because they represent a non-malignant invasion of normal tissue and such a condition is not recognized by pathologists as occurring anywhere else in the body.

It is recognized that many adenomyomas are found accidentally at operation and apparently do not cause symptoms. In other cases they may cause symptoms or may endanger the life of the patient.

In some cases removal of the tumor is indicated, but in other cases bilateral oophorectomy, use of radium or roentgen rays is a safer and quite as satisfactory a method of controlling the condition.

In the past 11 years a diagnosis of adenomyoma has been made 681 times from tissue removed from 574 patients at The Mayo Clinic.

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DISCUSSION.—HENRY T. HUTCHINS, M.D. (Boston, Mass).—Many strange pathologic conditions are present in the human body which still await an adequate explanation. It would seem that perhaps these occur more frequently in the female than in the male. Not the least of them, and one of the most interesting from a surgical standpoint, is the condition under discussion, which we call endometriosis—in other words, a hyperplasia of endometrial-like tissue in parts of the abdomen and pelvis where we have no reason to

expect endometrial tissue to be present. How this tissue is transplanted does not form a part of this discussion, but what symptoms it causes and what can be done surgically to relieve these symptoms constitute the situation with which surgeons are confronted.

As Doctor Masson has so well expressed it, these lesions represent a non-malignant invasion of normal tissue, a condition not recognized anywhere else in the body. It is probable that the attention of gynecologists has been more forcibly called to this condition than has that of the general surgeon, because we are operating constantly in the field where these tumors and implantations occur. I want first to call attention to the early recognition of these tumors in order that more conservative treatment may be carried out. As seen in the pelvis, and I am speaking now only of the endometrial peritoneal implants and not of the uterine adenomyomas, we see first only a small black dot often the size of the head of a pin and resembling a small petechial hemorrhage. This is the telltale lesion which is so frequently overlooked. It may be found anywhere in the lower abdominal cavity, on the appendix, on the ileum, on the sigmoid, and of course on the prevesical peritoneum and in the culdesac. This tiny lesion antedates the later adherent stage which is more easily recognized. Although only one of these black spots is seen, both ovaries and the entire pelvis must be searched for the initial endometrioma. When recognized in this early stage, I believe that in the young woman under 35 years we may be conservative in our treatment. The chances are that the initial lesion will be found in one ovary only. It is my practice in these early cases to remove only the ovary which is diseased. Following this conservative treatment many pregnancies have resulted, and the normal ovarian functions will be retained. The patient should, however, be kept under observation for a period of at least five years in order that we may detect the onset of any invasions of a recurrent lesion—invasions especially of the rectum, rectovaginal septum and bladder. In patients over 35 years of age, all ovarian tissue should be removed for it is known that the ovary furnishes the stimulus to the growth of these implants, and no matter how extensive they may be, the tissue will retrograde if all ovarian substance is removed.

The surgical complications of this disease are almost always caused by the invasion of normal tissue by a definite growth, and by far the most serious, as I have seen it, is the invasion of the wall of the rectum causing an increasing constipation due to a gradual stenosis. I have several times mistaken these growths for carcinoma both after roentgenologic examination and also after having opened the abdomen. The recognition of the lesion in the ovary has so far saved me from any resections of the sigmoid or rectum, even with a maximum degree of obstruction. These patients have all recovered and the bowel has returned to normal following complete removal of ovarian tissue.

It is probable that some cases of endometrial implants become in time carcinomatous, but I do not feel that this is fully proven at present. Cases have been reported of associated carcinoma, especially of the rectum, but we have no positive pathologic evidence that the carcinoma originated in the endometrial implant. I have not had a case that has developed carcinoma following an operation for endometriosis although I have seen associated cases.

This disease, as Doctor Masson has so clearly brought out, is difficult to diagnose before operation—in fact, in the early stages it is impossible. When once the lower abdomen is opened, however, it is well, before inserting the hand, to inspect the peritoneum carefully for the small black superficial dots which will lead one to suspect the condition. The treatment will then become conservative in the younger and radical in the older patients. The worst that

can happen to the younger patients is a later operation for removal of the other ovary, and the older patients will be permanently cured.

I agree with Doctor Masson that deep roentgen ray therapy should not be used in these patients. In the young, large sterilizing doses must be given, following which the patient cannot become pregnant, if this is desirable, and in the extensive adherent lesions a real pelvic peritonitis can be induced.

I believe it is important when performing any operation in the lower abdomen and pelvis to search for and recognize these small telltale bluish-black spots on the peritoneal surfaces so that there shall be no possibility of overlooking an early endometriosis with its consequent serious involvement of the bowel, bladder, and rectovaginal septum.

DOCTOR GATEWOOD (Chicago, Ill.).—Once in every so often gynecologists seem to discover something new and proceed to confuse the minds of their less imaginative colleagues, the general surgeons, with their discussions. Some years ago, it was ovariectomy, then retroversion, and later vaginal versus abdominal hysterectomy. Recently, it is endometriosis, endometrioma, heterotopic endometrial tissue, adenomyosis, *etc.* This condition may have been recognized before Babes described it in 1882, but it certainly made no great impression on surgeons until Sampson's rather startling observations in 1921 and 1922, in which he demonstrated the frequency of this condition. Since then innumerable articles have appeared championing the transplant theory of Sampson, the wolffian remnant theory, the Müllerian theory, or that of some type of serosal heterotopy. There are many arguments against the theory that implantation of dying desquamated epithelium will grow and produce mesothelial as well as epithelial cells. To these Doctor Masson has added still another good argument. The theory that the tissues of the coelomic cavity may revert to endometrium-like tissue fails to explain why such tumors never occur above the level of the navel. It is also difficult to explain those cases of adenomyosis in the umbilicus itself which are entirely extraperitoneal. Although endometriosis has been seen most often in or on the pelvic peritoneum, it is frequently found also in the uterus itself, in the ovary, in the wall of the cecum and sigmoid, on the bladder and in the umbilicus.

In 1932, Spitz collected 54 cases of umbilical endometriosis and since then several cases have been added, bringing the total up to nearly 70 with the six cases reported by Doctor Masson. To these I would like to add two cases which I have seen at the Presbyterian Hospital.

CASE REPORTS

CASE I.—(Presbyterian Hospital Case 303993.) A Mexican female, 43 years old, entered the hospital March 29, 1935, with the following complaints: mass at the umbilicus which had been present for about five years; swelling of the tumor mass at menstruation; pain, developing one day before menstruation and lasting throughout the period; discharge of dark bloody exudate from the umbilicus with each period. The past history was essentially negative. The patient had been married 18 years. She had had two children and one miscarriage. Her menses began at 15 and were regular.

On examination, the umbilical region was a dark bluish color with a nodular mass about the size of a pea protruding from the upper half (Fig. 3). There was a firm ovoid area about three cm. in its transverse diameter in the region of the umbilicus. The margins of this mass were rather indefinite. At operation, an elliptical incision was made about the umbilical region and the entire indurated area was excised. The incision was carried downward in the midline so that the pelvis could be explored. No evidence of endometrial transplants were found on the uterus or on the pelvic peritoneum. The abdominal wound was closed in the usual way except that the fascia was overlapped in the region of the umbilicus. On examination of the specimen the peritoneal surface

was smooth and glistening, and on cut section there was no evidence of attachment of the serosa to the tumor mass. The mass itself was firm in consistency, contained many bluish and brown cysts varying from one to five Mm. in diameter. Microscopic sections (Fig. 4) show the typical arrangement of stroma about tubules lined with columnar epithelial cells which is characteristic of the picture of endometrioma or adenomyosis.

CASE II.—(Presbyterian Hospital Case 289250.) A Polish woman, aged 44, entered the hospital November 23, 1933, on the service of Dr. Carl B. Davis. She complained of a small tumor of the navel which had been present for one year and which had bled at the time of her periods. She stated that something like a tablespoon of blood was discharged at each menstrual period. Except for pneumonia in 1923, her past history was negative. Menstruation began when she was 15 years old and was regular and of the 28-day type. The patient had one child, 23 years old. On examination, there was a firm, purplish mass about 1 cm. in diameter in the lower half of the umbilicus. This was covered with epithelium and not discharging at the time of examination.

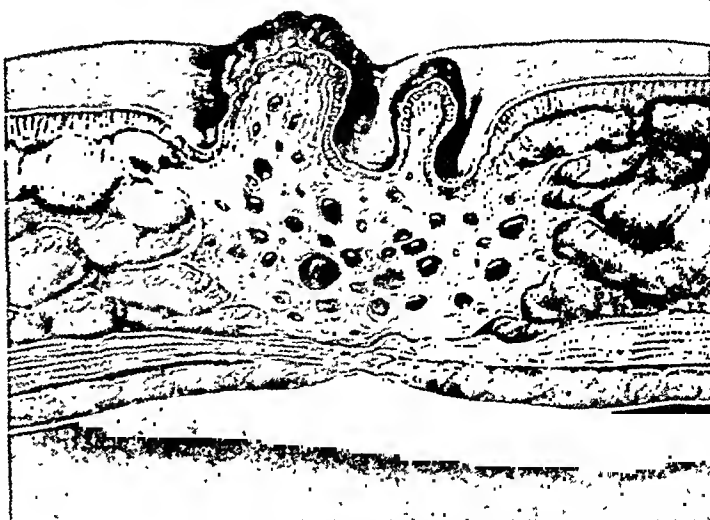


FIG. 3.—Drawing of longitudinal section of endometrioma of umbilicus, showing cystic formation (Presbyterian Hospital Case 303973).

At operation a transverse elliptical incision was made, excising the umbilicus and the tumor mass. A small umbilical hernia containing some omentum was also present. The defect was closed by the Mayo method of imbrication.

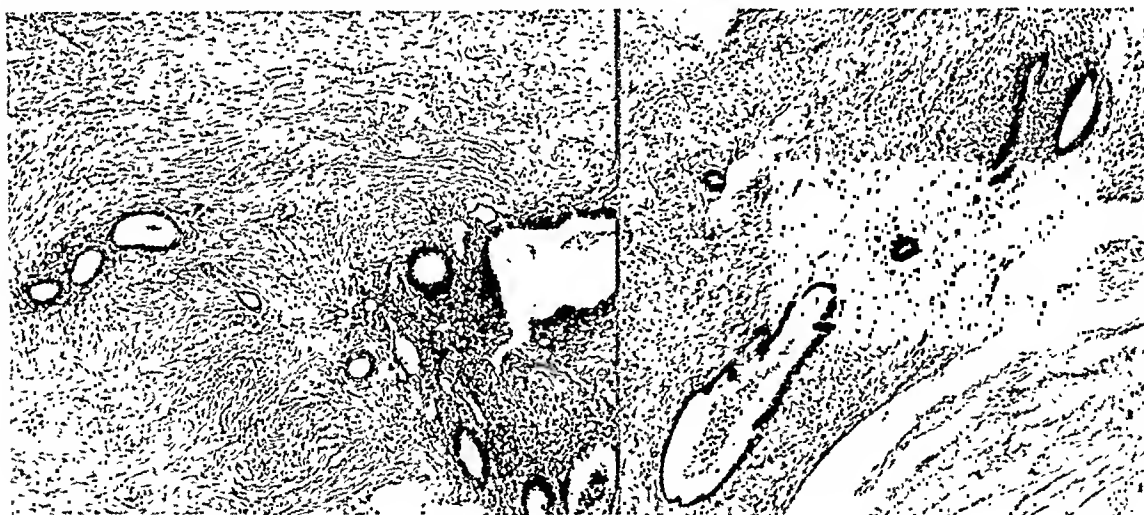


FIG. 4.—Microscopic section of specimen removed from Case I, showing typical arrangement of stroma about tubules lined with columnar epithelium.

FIG. 5.—Microscopic section from Case II, showing desquamation of cells in lumen of a tubule. Note typical arrangement of stroma.

Examination of the specimen showed a smooth peritoneal surface. On section, a firm mass containing small dark colored cysts was found. Microscopic section showed typical endometrial tissue (Fig. 5).

Far be it from me, a mere general surgeon, to enter into the gynecologic dispute as to the etiology of endometriosis. It is quite probable that no single theory can be made to fit all cases, although I should like to suggest a pos-

sibility which would explain the umbilical tumors as well as those within the abdominal cavity. Dr. John Beard, in an excellent series of articles published in the *Journal of Anatomy and Physiology*, in 1904, entitled "The Germ Cells," maintains that in the skate—and probably also in man—the germinal epithelium does not come from the genital ridge as taught by Waldeyer, and as usually accepted by advocates of the serosal heterotopic theory, but develops in the segmentation cavity of the future embryo and subsequently wanders into it. A considerable number of these germinal cells have been shown to never reach their proper destination in the germinal ridge and may be found without as well as within the abdominal cavity. This view will explain the origin of some of the peculiarly situated dermoid tumors as well as these cases of adenomyosis or endometriosis.

DR. EDMUND ANDREWS (Chicago, Ill.).—I should like to say a word about a series of four cases of endometriosis with which we have had to deal, three of which were situated in the abdominal wall. It is interesting that all three of the cases with abdominal wall growth were referred to the hospital with the diagnosis of an incarcerated hernia. One of them, however, was seen at the time of the menstrual period and the diagnosis was perfectly obvious. The second case was also diagnosed, but the third was not.

One of the points I should like to ask Doctor Masson is the choice of the time of operation for these cases. One case had the endometrial implant in the umbilical region, and was accompanied by a hernia. The hernia was not diagnosed. We thought it was simply endometriosis. Another case was in the inguinal region. It was small, gave a clear-cut history that was recognized at once. It was seen about two weeks after first examination during menstruation, and obviously smaller and not particularly painful. The woman had been sent in with the diagnosis of hernia. We assured her it was not hernia, and if the condition did not spread or get any worse, operation was advised against. We have not seen her since. That was two years ago.

I should like to ask Doctor Masson—the indications in the other two cases—the first case was an implant in the rectus muscle and it was near, but not in the scar of a previous laparotomy. We operated at the time when the hemorrhage and menstrual reaction was at its height. We then appreciated that it would have been better to have deferred the operation until later. Therefore, the second case was operated on during the intermenstrual period and was very simple, but it left us also with the impression that we had done wrong because it was so difficult to recognize the extent of the endometrial tissue. I think one is between the devil and the deep blue sea, in that the operation at the height of reaction is difficult and bloody, whereas if it is not done at that time, one closes up with the fear he has not excised enough tissue because at the intermenstrual period the tissue is gray, not red. It had not the faintest resemblance to that which we had removed before, and it would be only under the microscope that we could be sure it was endometrial tissue.

DR. CARL EGGERS (New York, N. Y.).—I have repeatedly had endometrioma reported on pathologic specimens in which it was not suspected. They were usually associated with tumor formation of the pelvic organs, most often fibro-angiomata, or ovarian cysts. Occasionally I have found them in other parts of the abdomen including the appendix. I have learned to recognize these tumors by their appearance. They are small, hard, ulcerating-looking-like lesions dark red or bluish-black in color, which cause marked puckering of the surrounding peritoneum, and suggest epithelioma.

It is largely because of the simulation of malignancy that they become surgically of interest and importance.

CASE REPORTS

CASE I.—My first experience with such a lesion was in 1929, when, after performing an hysterectomy for fibroid uterus in an unmarried woman, F. H., 43 years old, I noticed a tumor of the sigmoid. The outer end of the left tube was adherent to it. After separating it the tumor was found to be very hard and looked like a typical scirrhus carcinoma. There was no enlargement of the mesenteric lymph nodes. About three inches of the sigmoid were resected and an end-to-end anastomosis done.

After opening the resected portion of gut it was found that the mucous membrane was not involved. The tumor was reported as endometrioma which had invaded the wall of the sigmoid to the submucosa. The convalescence was uneventful. There has been no trouble since.

CASE II.—Later that same year, 1929, another patient with an endometrioma was operated upon by me, who had a very interesting history. Mrs. C. T., 37 years old, a married woman, had been under observation and treatment from time to time for six years. In June, 1923, I had operated upon her for an intracanalicular fibroma of the left breast. In October of the same year she had a curettage done, together with a right salpingo-oophorectomy, a left partial oophorectomy and ventrosuspension. The pathologic diagnosis was multiple cysts of follicular origin with hemorrhage. She was much improved after that except for some pain in the left lower abdomen apparently due to disease of the remaining portion of the left ovary.

In 1926 she had first begun to complain of having blood and mucus in the stool, associated with diarrhea. At that time pelvic examination showed a normal sized uterus in good position. A small tender mass was palpable in the culdesac behind the cervix. Abdominal and digital rectal examination were negative. Proctoscopic examination and a barium clysma showed nothing abnormal. A diagnosis of colitis was made. During the next few years she placed herself under the care of different medical men and gastro-enterologists. Her symptoms continued, she became discouraged, lost weight and strength and became quite anemic with hemoglobin of 58 per cent and red blood corpuscles of 3,600,000. Repeated proctoscopic examinations had been reported negative. On several occasions she had been confined to bed and had been given rectal instillations and other treatment. She had noticed repeatedly that the attacks were worse just before and during her menstrual period, but no special significance had been attached to this. She was eventually told that her loss of blood was due to hemorrhoids and that an operation was indicated. It was at this time she again came under my observation. Her chief complaints were pain over the left lower abdomen, attacks of bloody diarrhea and loss of weight and strength.

General examination as well as examination of her blood showed no evidence of constitutional disease. The general abdomen was not distended, but an elevation was noticed over the left lower quadrant, which on palpation felt like a rounded, non-tender mass, apparently arising from the pelvis. Vaginal examination showed the uterus slightly enlarged, and nodular, crowded over towards the right. On the left side a large cystic mass was palpable. A diagnosis of ovarian cyst was made.

Rectal examination was negative. A six inch proctoscope showed nothing abnormal. A longer proctoscope could not be introduced on account of distortion of the sigmoid, apparently the result of pelvic tumor formation. Operation was decided on to remove the pelvic mass and in the hope of finding a condition responsible for the rectal bleeding. It was three years after onset of symptoms connected with the colon and rectum that she was operated upon in July, 1929.

The old median incision was reopened, the omentum was found somewhat adherent to the scar but the loops of small intestines were free. A large cystic mass presented on the left side. It had displaced the sigmoid upward and towards the right. The mass was apparently multilocular. It was very adherent and difficult to liberate. Great

care had to be used not to injure the sigmoid or its vessels. For better access the cyst was punctured with a trocar and considerable clear yellowish fluid evacuated. The mass was then completely freed and removed. It was apparently composed of the ovary and tube. The uterus was nodular, and densely adherent to the anterior surface of the sigmoid. It felt as if one of the fibroids had grown into its wall. It was impossible to free the uterus from above downward posteriorly because of the extensive attachment to the sigmoid. The uterine vessels were therefore ligated on both sides, the cervix was divided and by drawing the uterus upward and backward it could be shelled off the sigmoid and removed. A slit about half an inch in length was noticed in the anterior wall of the sigmoid at the site of attachment. The sigmoid was now completely freed and the injured portion brought into the wound when it was found that it was an upper portion of the sigmoid which had been drawn into the pelvis. Palpation of its lumen revealed a tumor within. The opening into the gut was not sufficiently large to deliver this tumor. It was therefore enlarged and the mass turned out. It was a solid tumor the size of a walnut, which arose from the anterior wall of the sigmoid with a base the size of a dime. The involved portion of gut wall was removed with the tumor. It did not look malignant and impressed us as either a submucous polyp or an endometrial implant. The slit in the sigmoid was closed transversely by means of chromic catgut mucous membrane suture, over which interrupted silk sutures were placed. Some of the appendices epiploica were fastened in place to protect the suture line. Exploration of the sigmoid showed no additional tumors. The cervical canal was cauterized and the stump closed with interrupted chromic catgut. The pelvic floor was peritonealized incompletely. One cigarette drain was passed well down extra-peritoneally into the depth of the pelvis and another cigarette drain was placed into the reconstructed culdesac. The abdomen was closed in layers. A transfusion was given immediately after operation.

The convalescence was uneventful. There was no leakage from the intestinal suture line and after the drains were removed the wound healed kindly. There has been no return of symptoms.

Pathologic examination showed multiple fibromyomata of the uterus, multiple cysts of the ovary, chronic salpingo-oophoritis and an endometrial implant with the structure of an adenomyoma involving the wall of the sigmoid and projecting into its lumen like a polypoid tumor.

The following is a description of this tumor.—Section of the separate tumor involving the sigmoid shows it to be an adenomyoma composed of smooth muscle bundles in disorderly arrangement, separated by a considerable amount of fibrous tissue. Scattered through the fibromuscular tumor are large and small endometrial islands or naked uterine glands. The glands vary considerably in size, and some of them have attained cystic proportions. They are regular or sacculated and are lined with a single row of cylindrical cells, some of which show on their free margins structures strongly suggestive of cilia. Some of the islands are very large and contain numerous glandular elements. There are scattered hemorrhages in the supporting cellular stroma and some of the gland tubules contain blood. The growth infiltrates the wall of the sigmoid and in places replaces the muscular coat. The sigmoid mucosa is extremely atrophic in places and shows extensive ulceration. In the better preserved areas it presents enlarged or cystic glands containing numerous goblet cells.

Section through the uterine wall at the attachment of the tumor shows hyperplastic smooth muscle containing a number of scattered endometrial islands similar to those described above, though usually smaller. Some of these are situated on the surface of the roughened area from which the tumor was removed.

CASE III.—Mrs. E. N., 44 years old. In 1934 while doing a total hysterectomy for a fibroid uterus, associated with an ulcerated cervix and bilateral ovarian cysts, a small hard tumor was discovered in the sigmoid. It looked like a typical scirrhus carcinoma. After consultation with the family physician immediate resection was decided on, remov-

ing a portion of sigmoid extending one inch above and below the tumor. An end-to-end anastomosis was done.

Upon opening the specimen the mucosa was found to be uninvolved. A frozen section was reported non-malignant. A later pathologic examination showed an endometrioma extending deeply into the muscle layers of the sigmoid. The convalescence was uneventful.

CASE IV.—M. S., 40 years old. In December, 1934, another similar case was operated on by me. The patient was an unmarried woman. She had one large hard fibroid arising from the fundus and reaching to the umbilicus, in addition to several small intramural tumors and bilateral ovarian cysts. The sigmoid was firmly adherent to the mass and a tumor was palpable in its wall. With great care it was possible to separate the gut, which looked puckered and contained a hard flat tumor in its wall. Endometrioma was diagnosed on the gross appearance and the presence of other smaller implants in the pelvic peritoneum. No resection done. Supravaginal hysterectomy with both tubes and ovaries done. Abdomen closed without drainage. Pathologic Report.—Endometrioma of sigmoid.

These cases illustrate the occasional clinical significance of endometrioma and call attention to the importance of being able to make a diagnosis on the gross appearance of the lesions.

DR. JAMES C. MASSON (Rochester, Minn.).—Judging from the numerous articles on endometriosis appearing in the medical literature there is no doubt that the subject is of real interest at the present time. Doctor Eggers' experience, I think, has been most fortunate, but if we could get the complete histories of all patients that have had similar operations (resection of the large bowel for benign tumors), I am sure we would find that a great many deaths occurred from an operation that could have been avoided, if the condition had been recognized before resection was undertaken.

Doctor Andrews' advice to operate in the interval between menstrual periods is sound. There is no doubt that the operation is simpler and safer at such times.

Adenomyomas or endometriomas of the abdominal wall are as a rule small in size and can be easily removed. It is important to keep well away from the growth, in fact taking a little normal tissue along with the tumor. It is possible that some tumors classed as desmoids are true adenomyomas.

In some of these cases I have had to do extensive resection of muscle, leaving a large gap that would predispose to hernia. I think it advisable to take care of the potential hernia at the same time. In these cases the use of living suture, as advised by Doctor Gallie in large herniae, has been a real help.

Doctor Hutchins brings up the question of small lesions so frequently recognized now by gynecologists. There is no doubt that many of them develop into tumors producing symptoms, but it is hard for me to believe that surgical removal is necessary in all cases.

In Sampson's work he reports in all his pelvic work finding about 43 per cent with some involvement. That same large number is reported from Doctor Lynch's Clinic. I have seen these lesions ever since I have been doing surgery. I never used to consider them, in themselves, dangerous unless there was some other definite involvement of the ovary. Most of them do occur where an ovarian cyst has ruptured and scattered endometrium or endometrial-like tissue throughout the pelvis. Sampson considers the ovaries to be like a hot bed for endometrium.

In recent years I have been taking these small lesions off, and it is surprising how frequently endometrium-like tissue is reported in the tissue removed.

OVARIAN TUMORS WITH ENDOCRINE SIGNIFICANCE

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IN THIS day and age discussions of the problems of endocrinology are filling the medical literature to overflowing. Many valuable facts are being added to our knowledge of the normal physiologic behavior of our glands. The pathologic dysfunctions, much more difficult to comprehend, are being slowly worked out step by step. In the study of pathologic conditions of the endocrine glands hyperplasias and tumors are among the most important findings. The understanding of hyperplasias is still in darkness but in some organs tumors having definite functions have been satisfactorily investigated. Such tumors secrete substances that profoundly change the normal individual and their removal is followed by a return to normal. Thus in some tumors the effect of a hormone can be observed and the proof of its potency can be clearly demonstrated.

The ovary is frequently the seat of such physiologic tumors and the recent medical literature contains many reports of such cases. This increased interest in ovarian tumors is due to the emphasis upon hormonology and for the most part our knowledge is directly attributable to the researches and writings of one man, Professor Dr. Robert Meyer,^{2, 3, 4, 5, 6, 7} of Berlin. He clarified for all of us the embryology, pathology, and physiology of the arrhenoblastomas, the disgerminomas, the granulosa cell tumors, and others. His observations have led to the frenzied search of old microscopic slides in our Pathology Laboratories. For the next few years all the great laboratories will be presenting reports of cases of odd or interesting ovarian tumors. That these tumors had been misunderstood and misdiagnosed was made clear to us at the Massachusetts General Hospital when seven granulosa cell tumors and five disgerminomas or seminomas were uncovered. These tumors were rediscovered in 1931 and later among a small proportion of all the ovarian tumors in that hospital. At present there is a much more comprehensive review in progress accompanied by a careful follow up of all the patients from whom the tumors were removed. Undoubtedly arrhenoblastomas and testicular adenomas have been overlooked and a careful study should bring more of these interesting growths to light. The presence of postmenopause bleeding and hyperplasia of the endometrium in various types of ovarian neoplasms points to the fact that probably many other types of growths secrete the female sex hormone or an allied substance.

It is the purpose of this paper to describe briefly the interesting characteristics of the now known group of physiologic neoplasms of the ovary and to

report in greater detail some of the characteristics of the disgerminomas and granulosal cell tumors found in our laboratory. In Table I are presented the now known types of ovarian tumors with definite endocrine significance.

TABLE I

Ovario-testis
Testicular tubular adenoma of Pick
Arrhenoblastoma
Hypernephroma of adrenal origin
Disgerminoma or seminoma
Granulosal cell tumor

The first three probably secrete the male sex hormone in varying degrees, producing hermaphroditism in some instances and masculinization, moderate to severe, in others. The hypernephroma of the ovary, and it must be a hypernephroma of adrenal origin, secretes the adrenal cortex hormone that produces the "infant hercules" in the male and the marked masculinization in the female. Such conditions are seen in true adrenal cortex hyperplasia, adenoma, and carcinoma. The disgerminoma or seminoma does not cause masculinization but in some manner retards normal development and is responsible for female hypoplasia. Considering the disgerminoma as a teratoma or twin of the host the maldevelopment of the latter might be explained as that usual in the "free martin" (the undeveloped female twin of a well developed male). The granulosal cell tumor is the only femininizing tumor in this ovarian series and it secretes the hormone estrin or theelin. Thus it is evident that most of these interesting lesions are male directed. The male is dominant in the human and female attributes are possible only through lack of male domination. In the male femininization is rarely seen. Gynecomastia has been reported in males with teratomas containing chorionic tissue. The absence of the male hormone only brings about a neutral state, while in the female removal of the female hormone even without the presence of any male hormone frequently changes the castrate toward the masculine side, for example the growth of hair, change of voice and fat distribution, and the hypertrophied clitoris of the menopause.

The testicle, the adrenal, and the ovary all originate together in one small area in the celomic epithelium and the testicle and ovary have a common ancestor in the embryonal inner and outer epithelial cell masses. The epophoron and the epididymis are homologues as are the paroophoron and the paradidymis, just as the rete ovarii is the counterpart in the ovary of the rete testis. With such a similar origin it is not difficult to understand how undifferentiated, indifferent, or even primitive male directed cells can be imprisoned in the ovary only to develop later at an opportune time. The origin of the cells of the granulosal cell tumor is in much greater dispute but the primitive cells that make up the original cells of the graafian follicle are probably responsible. That the granulosal cells of the adult follicle are responsible is somewhat questionable. In this hot bed of embryologic remains it does not seem unreasonable to assume that primitive testicular or primitive

ovarian cells may be preserved until some stimulation causes them to grow and produce their hormone.

THE TUMORS

The ovario-testis is a benign lesion. It is an embryonal abnormality and probably not a true tumor. Its origin is attributed to normal testicular cells

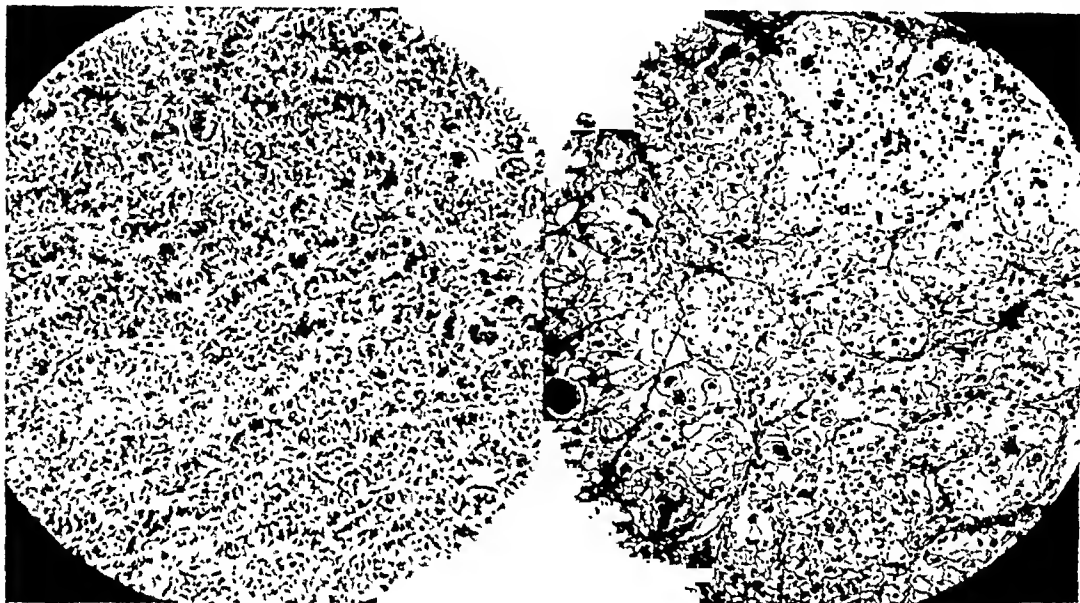


FIG. 1.

FIG. 2.

FIG. 1.—Arrhenoblastoma. Photomicrograph of a slide given the author by Prof. Dr. Robert Meyer. Short epithelial cords with a rather characteristic appearance. Numerous dilated endothelial centers are frequently seen.

FIG. 2.—Tumor of the ovary suggesting hypernephroma or a tumor of renal origin. Such a tumor with masculinization of the patient would suggest a suprarenal lesion.

persisting in a developing ovary. A fairly true testicle is formed which is dominant over the weakened ovary. This monstrosity may be responsible for hermaphroditism and masculinization and its removal, if all testicular parts can be excised, returns the patient to normal, provided the anatomic development of a hypo- or epispadias has not progressed too far.



FIG. 3.—Photomicrograph of a disgerminoma. The nuclei are large, and mitotic figures are not infrequent. There is usually a stroma of connective tissue containing many lymphocytes between the groups of cells.

The testicular tubular adenoma was first described by Ludwig Pick in 1905. In this tumor there is an adenomatous development in the testicular portion of the ovary. Frequently this occurs in the ovario-testis but it may be present in lesions not of the ovario-testis type. Microscopically this tumor cannot be distinguished from the testicular tubular adenoma of the testicle. This adenoma, classified as one type of arrhenoblastoma

OVARIAN TUMORS



Mural McLoche
1931

FIG. 4.—Disgerminoma, a solid, smooth, lobulated tumor. Its appearance is characteristic of a very malignant lesion.

by Meyer, is the least masculinizing of the group. The more differentiated toward the normal the arrhenoblastoma is the less masculine the victim. On removal of such an adenoma the patient becomes refeminized if only one small ovule is left in the remaining ovary.

The arrhenoblastomata are of different types. They arise from the undif-

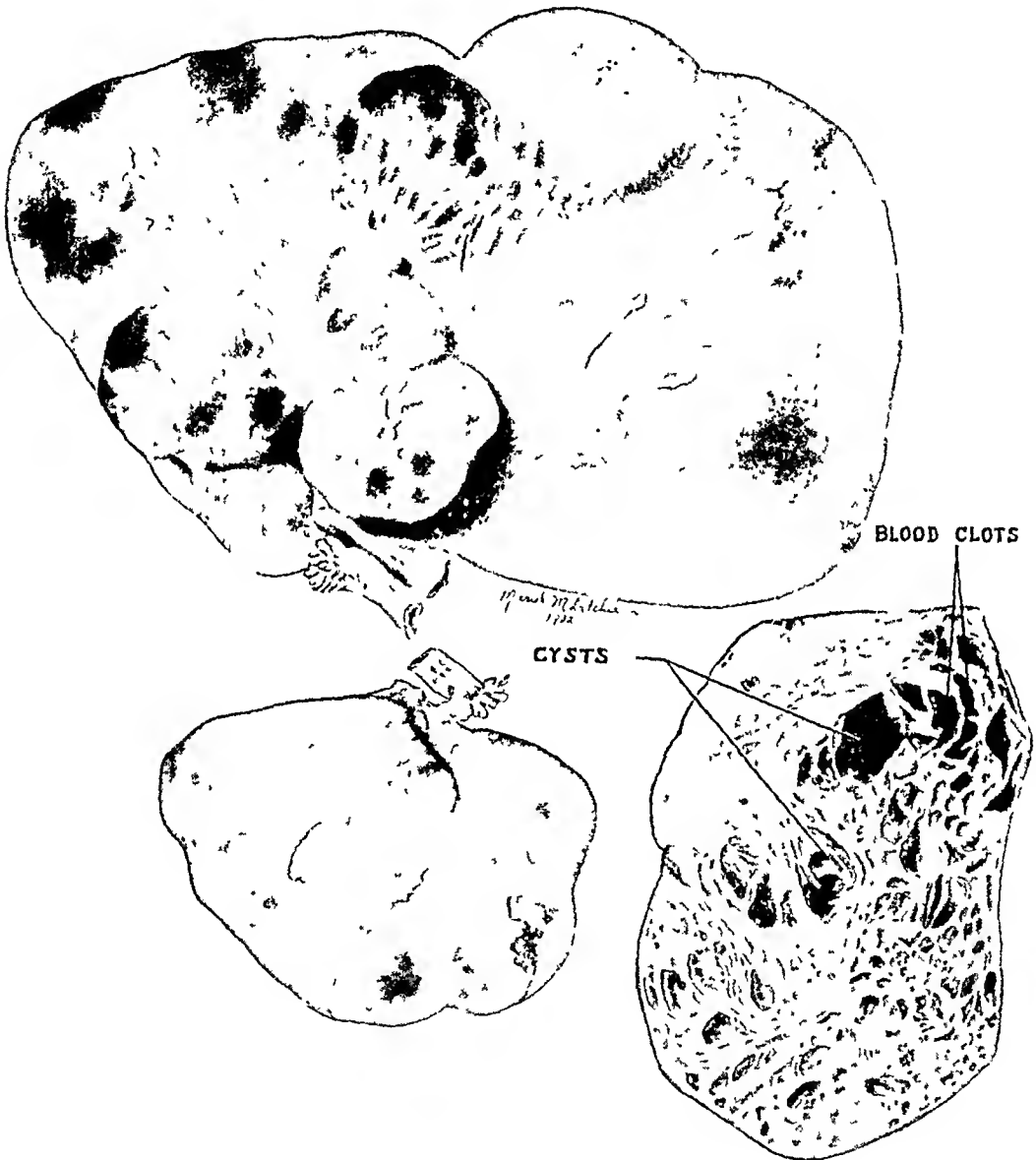


FIG 5.—Granulosa cell tumor, a solid and cystic lesion of smooth, lobulated appearance. Usually unilateral

ferentiated germ cells or indifferent sex cells and produce a semi-malignant or very malignant semi-solid or cystic tumor. The complexity of the pathologic picture (Fig. 1) is great but short wavy epithelial cords plus dilated endothelial cavities are characteristic. The tumor secretes an abundance of the male hormone and is responsible for considerable masculinization. The patient loses her scalp hair; grows hair on the shoulders, upper arms, and thighs; the breasts atrophy; and the bony framework of the body suggests the masculine. The abdominal hair has a masculine distribution, striae

are present, the clitoris enlarges, amenorrhea develops, and the voice changes. Removal of such a tumor allows the patient to revert to normal, all except the voice change, which may be permanent. Such a tumor may recur and in so doing the patient again becomes masculine in type.

Hypernephromas of the adrenal type in the ovary are rare lesions and but few of the reported ones have been authenticated. These lesions, secreting as they do the same hormone as the adrenal cortex, hyperplasias and tumors, produce a masculinization similar to that of the arrhenoblastoma. The tumor is regarded as malignant and its removal allows feminization to develop. One slide (Fig. 2) in our series was very suggestive of this type of lesion but it is possible that the tumor was of the kidney hypernephroma type as no masculinization was evident in the patient.

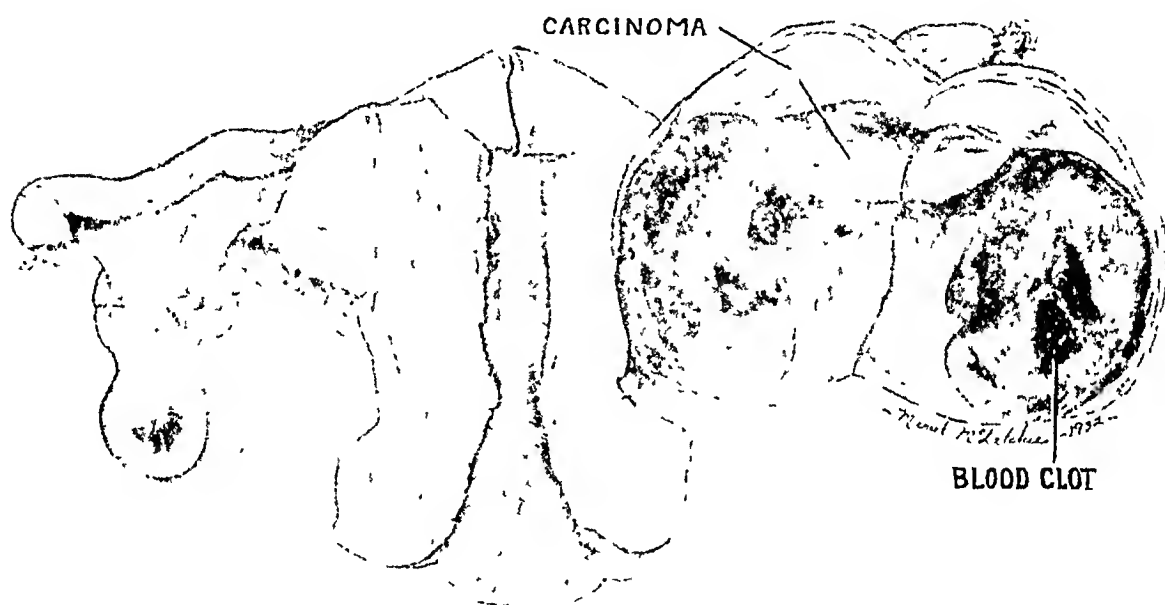


FIG. 6.—Granulosa cell tumor, a smooth tumor about 6.5 cm. in diameter. There is a light solid area of tumor and the dark areas are blood clot.

The dysgerminoma or seminoma is a tumor originating in the indifferent sex cells of the ovary. This is a tumor of youth and its hormone is potent enough to prevent proper female development in some cases and disturbances of the menses in others. It is a large round cell carcinoma with large nuclei and the stroma between masses of these large cells is full of lymphocytes (Fig. 3). The microscopic picture is characteristic. This tumor which looks very malignant (Fig. 4), as do all solid carcinomas of youth, is apparently not severely so, as of five cases that have come to our attention four are alive and well over four years. In one of our cases the tumor was responsible for a serious under development of the patient. The other ovary was minute, the uterus infantile, and the breasts under developed. Both ovaries were removed at the operation so it can never be known whether or not the patient would have developed properly once the tumor was removed. One other of our patients who had a menstrual dysfunction when the dysgerminoma was present gave birth to a child seven years after her operation.

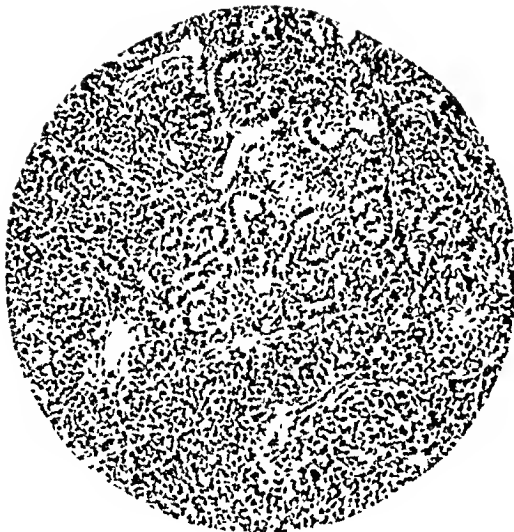


FIG. 7.

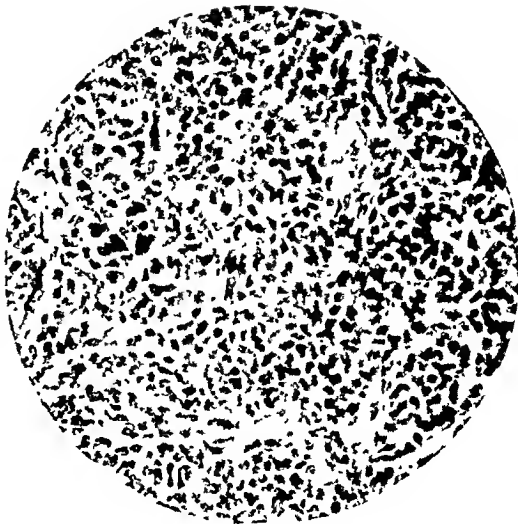


FIG. 8.

FIG. 7.—Photomicrograph of a granulosa cell tumor—low power. The cells are like the granulosa cells of the graafian follicle. Attempts to create active follicular structures are plainly seen.
FIG. 8.—Photomicrograph of a granulosa cell tumor—high power. The cells are very regular and of about the same size. Their resemblance to granulosa cells is very striking.

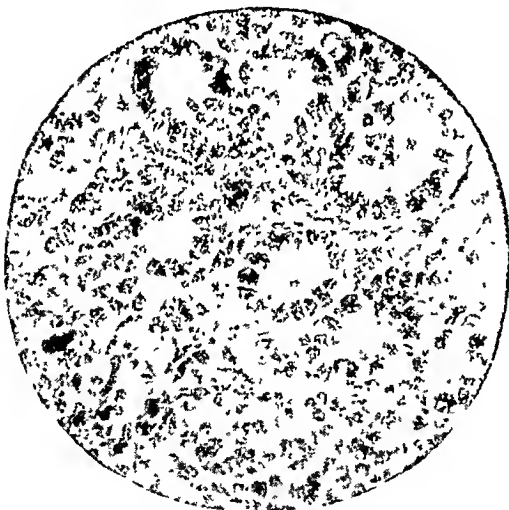


FIG. 9.

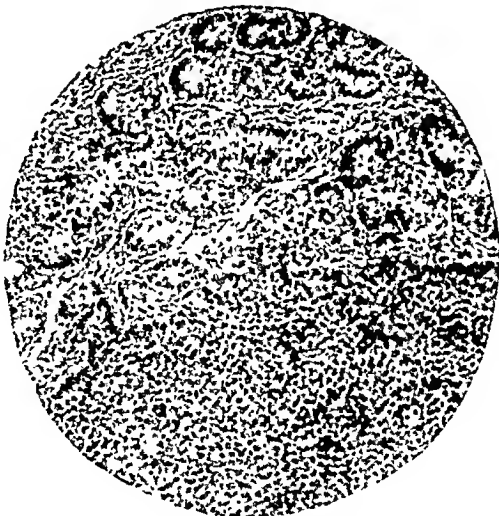


FIG. 10.

FIG. 9.—Photomicrograph of a granulosa cell tumor—high power. Here the attempt to create follicles is evident.
FIG. 10.—Photomicrograph of a granulosa cell tumor—low power. The tubular type of tumor. Notice the regularity of the cells in the lower part of reproduction. These have the appearance of typical granulosa cells.

TABLE II

Disgerminoma—Seminoma

5 cases—25, 23 (2), 18, 12	
Undeveloped genitalia.....	1
Abnormal catamenia.....	3
Living 9 yrs., 8 yrs., 7 yrs., 4 yrs.	
Dead 1—extensive at time of operation.	

The granulosa cell tumor (Figs. 5 and 6) is both benign and malignant. It originates from the follicular apparatus whether primitive or adult. The cells lining the graafian follicle are granulosa cells and the tumor closely resembles masses of these cells. Although it grows in tubular, sarcomatous, and follicular type it is usually easy to diagnose microscopically (Figs. 7, 8, 9, and 10). They were incorrectly called sarcomas or embryonal carcinomas in the first laboratory study. Tumors of this type are responsible for precocious femininity and early menstruation in young girls and such children



FIG. 11.—Photomicrograph of the endometrium in a case of granulosa cell tumor. Hyperplasia of the swiss cheese type is clearly shown.

should be considered as possible hosts of the lesion. Removal of the tumor checks the femininization and the child reverts to normal. In adults this lesion is responsible for abnormal bleeding of the estrin type with hyperplasia of the endometrium (Fig. 11). Removal of the tumor corrects the abnormal menstrual flow. In older women past the menopause they cause hyper-femininization as evidenced by menstruation of the non-ovulatory type occurring either as continuous, irregular, or periodic bleeding. Removal of the lesion stops the abnormal flow. In any patient in adult life and especially in those past the menopause the presence of bleeding and hyperplasia necessitates a careful search for such a tumor. The neoplasms are frequently malignant and radical surgery is perhaps best. Of seven cases seen at the Massachusetts General Hospital all were under 50 years of age and of these two have died of their cancer.

TABLE III
Granulosa Cell Tumor

Ages—26	1	Bilateral.....	2
33	1	Fibroids.....	1
36	1	Endometrium examined.....	2
39	1	Hyperplasia.....	2
41	2	Solid.....	3
42	1	Sarcomatous	3
Married.....	7	Tubular.....	1
Children.....	6	Living (2.5 years and 5 years).....	2
Menorrhagia.....	2	Living without disease (7 months and 8	
Regular periods.....	3	months).....	2
Brown discharge.....	1	Lost.....	1
Amenorrhea (menopause)	1	Dead (1 year and 2 years).....	2

Below in brief outline are presented the histories, physical and pathologic examinations of five cases of dysgerminoma or seminomas and seven cases of granulosa cell tumors.

CASE REPORTS

*Dysgerminoma—Seminoma**Five cases*

CASE I.—L. M. C., aged 23. Single. Complaining of diarrhea for two months and pain in the right side. She noticed enlargement of the abdomen eight months before. Her periods began at 13 and had always been regular. She was well developed and nourished with no abnormality of secondary sex characteristics or abnormality of sex feelings. Physical examination showed a large mass in her abdomen. At operation a large ovarian tumor was removed. The tumor measured 21 cm. by 19 cm. There is no record of the gross description of the tumor. The microscopic picture was typical of a dysgerminoma or seminoma. This patient was seen and examined in April, 1935, and found to be perfectly normal nine years after the original operation.

CASE II.—H. H. 31:437. L. A., aged 18. Single. Complaining of abdominal swelling with intermittent dull and sharp pain. Her periods began at 13 and gradually assumed a 28 day cycle. Lately she has been flowing four to five days early. The patient was well developed and well nourished. There was a large mass in her lower abdomen. At operation a heavy, knobby tumor, partially twisted, was found filling the lower half of the abdomen. It was removed. The pathologic report showed a tumor of the ovary, 17 cm. by 14 cm. It was lobulated, irregular, and pale pink. On cross section it was a soft cellular new growth with areas of hemorrhage. A diagnosis of embryonal tumor of the ovary (adenocarcinoma type) was made. The slides of this tumor are characteristic of the dysgerminoma (seminoma). In May, 1935, four years after the operation, the patient without further treatment is alive and well and normal in appearance without evident disease.

CASE III.—M. G. H. 261448. V. K., aged 12. Single. Complaining of lump in middle of her lower abdomen of one and one-half month's duration. This lump had grown slowly in size. Periods began four months ago and since then the patient has had two periods and skipped two periods; alternating. The patient was a well developed and well nourished girl. Physical examination showed a mass in the pelvis which could not be differentiated from the uterus since the cervix apparently was continuous with the mass or the uterus was adherent to it. At operation a solid, lobulated, vascular tumor springing from the right ovary was found and removed, leaving the right tube. The

pathologic report showed a solid, spherical tumor, the size of a cantaloupe, measuring 9.5 by 14.5 by 16.5 cm. Its surface was smooth and nodular. On section it was moist and grayish-white with small, yellowish, opaque areas. Microscopic examination showed alveolar clusters of large undifferentiated epithelial cells and reactionary stroma. Picture was typical of seminoma or disgerminoma. In February, 1931, seven years following operation, a baby was born to the patient and she was seen eight years following the operation and was feeling very well. Menstruation has been normal since the first month after childbirth.

CASE IV.—M. G. H. 235259. J. W., aged 23. Married. Three children. No miscarriages. Complaining of lump in right side of three years' duration. This grew very slightly but caused her no trouble until three weeks ago when she noticed increased abdominal enlargement at the site of the tumor. There was no pain but the tumor was tender. The patient has been flowing every day for the past two weeks. Periods were regular until eight years ago since which time they have not been so regular. She has slight dysmenorrhea. The patient was poorly developed and very poorly nourished. Physical examination showed a mass easily felt on pelvic examination. There was tenderness on the right side. At operation a large, nodular, hard tumor was found arising from the left ovary and filling the pelvis and lower abdomen. The upper two-thirds of tumor was amputated, and the right ovary which was cystic was removed. The peritoneum was studded with nodules. The liver was free of disease. The pathologic examination showed an irregular solid tumor, measuring 10.5 by 12.5 by 21 cm. with a smaller mass about the size of a small orange, the combined weight of the two being 1,480 Gm. On section it was composed of a homogeneous soft white surface with small areas of opaque yellow softening. Microscopic examination showed solid masses of undifferentiated epithelial cells, among which are groups of small cells, the size of lymphocytes. There is a variable amount of stroma. The slides of this tumor were characteristic of seminoma or disgerminoma. The patient was given five radium treatments over a period of five months. She died one and one-half months following treatment.

CASE V.—M. G. H. 263006. E. C., aged 25. Single. Complaining of pain in the left lower abdomen, "nagging" in character, of two months' duration. Vomiting with last two attacks of pain. Patient had never menstruated. She was well developed and well nourished, of a stolid type. Breasts were not developed and she had sexual infantilism. Physical examination showed a soft, level abdomen with some tenderness in the right and left lower quadrants. Slight rigidity but no spasm. There was a mass three to four cm. in diameter in the region of the left kidney. Genitals were undeveloped for patient's age. On rectal examination she was found to have a small retroverted uterus. At operation a small, diminutive cervix was revealed, into which a small probe passed for a distance of about one to one and one-half inches. Abdominal exploration revealed a pelvis with a diminutive ovary on the right. In the posterior cul-de-sac there was a dark blue solid growth which proved to be a solid tumor of the left ovary, as large as a tennis ball, the pedicle of which was twisted one and one-half times. Both tubes, left ovary and tumor, and what may have been the remnant of ovarian tissue on the right were removed. The pathologic report described a spherical solid tumor with deep purplish-red surface and oviduct attached. On section it was 4 cm. in diameter and showed a soft, dull, purplish-red surface. The other oviduct also had a purplish-red surface. A small yellowish nodule was seen in the broad ligament below it. Microscopic section of ovarian tumor showed a tissue which was largely necrotic and filled with blood and wandering cells. In places alveolar clusters of large atypical epithelial cells, somewhat degenerated, were found. No ovarian substance was identified in the nodule in the broad ligament. The slides were characteristic of disgerminoma. On examination of the patient in April, 1932, seven years after operation she was found to have markedly infantile breasts, small and cone shaped, very sparse hair on the vulva and mons veneris. The labia minora were practically gone. The vagina was extremely infantile and could

be just entered with the finger. The cervix was not felt. On rectal examination nothing was demonstrable in the pelvis. The patient had marked genital and breast infantilism. She wished to be married and was advised to do so providing her husband knew she could not have children. The patient has never menstruated.

Granulosa Cell Tumors

Seven cases

CASE I.—M. G. H. 277980. S. S., aged 41. Married. One child. No miscarriages. Complaining of excessive flowing for four months. Three years ago she had a lump in the lower abdomen and pain which lasted only a short while. Sixteen months ago she was curetted for excessive flowing. She has passed large clots at times. Periods were always irregular with only a small amount of bleeding. Patient was well developed and well nourished. Physical examination showed vaults clear and fundus in anterior position and moderately enlarged. At operation a right ovarian cyst, the size of an orange, was found and ovaries were removed. Pathologic examination showed a cystic tumor 6.5 cm. containing mushy, wet, yellowish material. Microscopic examination showed a richly cellular growth. Cells were not differentiated and were small. The slides were characteristic of granulosa cell carcinoma. Follow up has not been successful.

CASE II.—M. G. H. 185045. N. D., aged 42. Married. Five children. One miscarriage. Complaining of fulness and abdominal distention after meals of two months' duration. Has felt rundown for several months. There has been increase in the size of the abdomen for 11 days. She has had frequency of urination for three months. Abundant flatus. Periods have always been regular. Occasional slight leukorrhea. Patient is well developed and well nourished. Physical examination showed nothing palpable on bimanual examination on account of distention. At operation two apparently malignant cysts of the ovaries the size of melons were found. Cysts and ovaries removed. Peritoneum and liver were covered with many small metastases. The pathologic report showed both ovaries enlarged to the size of an orange, dark red and lobulated. On section there were multiple cysts, some filled with clear fluid and others with solid tissue which had a soft grayish-white surface on section. On microscopic examination of the solid growth there were large masses of epithelial cells separated by a little stroma of connective tissue. Slides were characteristic of granulosa cell carcinoma. The patient died two years following operation.

CASE III.—M. G. H. 237812. A. McK., aged 36. Married. One child. One miscarriage. Complaining of excessive flowing with periods, of 11 months' duration. Slight flowing between periods occasionally. Periods were irregular and slightly painful until operation for removal of cervical polyp eight years ago. Patient was fairly well developed and well nourished. Physical examination showed a rounded tumor in the left culdesac which felt like a cystic ovary or pedunculated fibroid. At operation a right ovarian cyst the size of a base ball was found. Pathologic report described a spherical semisolid tumor the size of a base ball. On section it formed a soft, solid purplish-red mass with one or two small cysts containing clear fluid. On microscopic examination there were solid masses of small undifferentiated epithelial cells in a fibrous stroma with a zone of ovarian tissue on one surface. Picture was typical of granulosa cell carcinoma. The patient was seen two and one-half years after operation and felt very well. No tenderness or masses felt in pelvis. There was a small nodule in the vaginal wall on the right side, the size of a pea; which was not felt to be a recurrence.

CASE IV.—M. G. H. 252102. M. W., aged 39. Married. No children. No miscarriages. Complaining of mass in right lower quadrant for one and one-half years. She believes it is getting progressively larger. Since this time she has noticed vague intestinal symptoms with occasional vomiting. She has urinary frequency—particularly at night. Periods are regular. No dysmenorrhea. Patient is well developed and nourished. Physical examination shows multiple masses palpable bimanually. At opera-

tion the pelvis was full of inflammatory material, the tumor masses were ovarian cysts. Left tumor was of the papillary adenomatous type. The cyst was shelled out of the pelvis and amputated so that a portion of the wall of the cyst was left adherent to the intestine. The left cyst was enucleated by shelling it out transperitoneally. Pathologic examination described a cystic and solid tumor the size of an orange. On section it showed a soft, cystic center and a grayish-white, fleshy cortex. On microscopic examination there were small undifferentiated epithelial cells having an alveolar arrangement, showing numerous mitotic figures. Slides were characteristic of granulosa cell carcinoma with metastases to the oviduct. The patient died one year following operation.

CASE V.—M. G. H. 326234. E. M., aged 26. Married. Three children. One miscarriage. Complaining of dull ache in right lower quadrant of seven years' duration (one month following the birth of the patient's first child). For the past two years the pain has also involved the left lower quadrant; more severe at time of periods. She has also had a foul smelling white to brownish discharge. Legs tire easily. Aggravation of symptoms during and after each labor. Menstrual history not known. The patient was fairly well developed and well nourished. Physical examination showed tenderness in both lower quadrants. There was swelling and tenderness in the region of the right Bartholin's gland. Vaults were free. At operation a Bartholin cyst was excised. A cyst of the right ovary, about 6 cm. in diameter, was found. Right tube and ovary were removed and the uterus suspended. Pathologic report described a cystic ovary measuring 5.5 cm. in diameter. The wall was thin and smooth. On opening it the cyst was filled with serum and lemon jelly-like material. The lining of the cyst was smooth. There was one corpus luteum and a white firm encapsulated tumor one cm. in diameter. On section this mass was firm and finely granular. The microscopic picture was typical of granulosa cell carcinoma. The patient was seen in August, 1933, seven months following operation and was doing well. Her periods were normal. No evidence of disease. No metastasis in vagina. Nothing to suggest recurrence by rectal examination.

CASE VI.—M. G. H. 268025. M. R., aged 33. Married. One child. No miscarriages. Complaining of increase in length of periods for about three years. Amount of flow was not excessive. Nine months ago she flowed steadily for nine weeks. Patient feels well except for weakness. Seven years ago she had a period of amenorrhea lasting for two years but periods then became fairly regular. Patient is well developed and well nourished. Physical examination disclosed a large tumor involving the fundus which was hard, freely movable, and rose nearly to the umbilicus in the left lower quadrant. Behind the cervix the tumor was prominent and had a small prominence on it. This was easily felt by rectum. At operation a solid tumor of the left ovary the size of a baseball was found. The right ovary showed no evidence of disease. The left ovarian tumor was first removed and incised for examination. The cut surface suggested malignancy so it was decided to remove the other ovary and do a hysterectomy on account of the excessive bleeding. On pathologic examination one ovary formed a solid tumor about the size of a tennis ball. On section it had a moist, pale yellow, fibrous surface with small cysts. The other ovary was small and showed a fibrous surface on section without evidence of new growth. On microscopic examination of the solid ovarian tumor there was a richly cellular growth composed of small cells with hyperchromatic nuclei which form compact masses with occasional distinct alveolar clusters. In places these cells differentiated into small compact tubercles. A fibrous stroma pervaded the tumor and ran between the cell masses. The slides were characteristic of granulosa cell carcinoma. Five years later a letter was received from the patient stating she was in the best of health.

CASE VII.—M. G. H. 319722. G. B., aged 41. Married. Three children. Ten miscarriages (chiefly stillbirths). Complaining of foul, whitish, vaginal discharge for two years. Also had pain across lower abdomen, and pain in lower back; aggravated just before period. Periods began at 16 and were regular every 28 days, flowing for five days. With no periods for four months she believed she had passed into the menopause.

Patient was fairly well developed and well nourished. On physical examination a cystic non-tender mass 3 cm. was felt in the left vault. In the right vault there was marked thickening but no definite mass. At operation an atrophic right ovary was found and an ovarian cyst of the left ovary 7 cm. in diameter with the omentum adherent on the posterior surface. The pathologic report disclosed one ovary as small and atrophic and containing a thin walled, smooth-lined, purplish colored cyst which had been opened and measured approximately 2 cm. in diameter. The other ovary was large, ovoid with a smooth, glistening, mottled, reddish-gray surface and measured 6.5 by 4 by 5 cm. in size. It was moderately soft in consistency and on section had a large and irregularly shaped area 4.5 by 2.5 by 3 cm. filled with blood clot and surrounded by a thin yellowish-brown corpus luteum 1 by 1 by 0.5 cm. near the upper pole. The remaining portion of the ovary had a very smooth, glistening, whitish lardaceous appearance. Microscopic examination showed the tumor to consist of small oval to spindle shaped cells of very uniform size with a tendency to alveolar arrangement and the formation of long cords or duct-like structures devoid of lumina. The picture was characteristic of granulosa cell carcinoma. The patient was given one series of roentgen ray treatments about eight months following operation. Seven months after operation she began to have bleeding and pain in hips. Roentgenograms were negative for metastatic malignancy.

SUMMARY

Tumors of endocrine significance are not rare and more diligent search should be made for them in the Pathology Departments of our hospitals. That such physiologic tumors secrete definite hormones may be assumed because of the numerous instances of cases that have been returned to normal following removal of the tumor. The ovary is the seat of a great many functioning tumors and it is possible that as we acquire greater understanding more lesions with important bearings upon the bodily habits will be discovered.

NOTE.—The drawings and photomicrographs in this article have been reproduced from the originals used in "Tumors of the Female Pelvic Organs" by Joe Vincent Meigs,¹ published by the Macmillan Company in 1934. The author wishes to thank the publishers for their courtesy.

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DISCUSSION.—DR. JOHN J. MORTON (Rochester, N. Y.).—It has been known for many years that hyperplasias or tumors in certain organs have produced substances characteristic of the tissues involved. The effects on the individuals concerned have varied from such outstanding changes as acromegaly, or increased basal metabolisms, down to scarcely demonstrable action. Some of the neoplasms, for instance, manufacture substances characteristic of the organ from which they are derived but the general effect on the organism is almost negligible. Thus, cancers of the stomach may make hydrochloric acid; bile duct cancers may secrete bile; or bone sarcomas may develop new bone—all of them, even in their metastatic deposits.

The changes brought about by overproduction of some endocrine substances whether formed in hyperplasias or true tumors are discoveries of relatively recent date. The profound disturbances in calcium metabolism of parathyroid origin; the upsets in sugar metabolism from tumors of the islets of the pancreas; the marked blood pressure regulating action of adrenal paragangliomas; and the sex changes associated with other tumors of endocrine origin have attracted investigators in recent years.

A great impetus was given to these studies when biologic tests for minute quantities of the endocrine substances became available. The causes of the changes in the sexual cycle were revealed for the first time and the relationships to changes in the secondary sexual glands were made out. The progress has been so rapid and from so many sources that at present the names used to designate these endocrine substances are many and varied.

There is little doubt that the endocrine substances released into the circulation by most of the tumors of ovarian origin have the power to modify the individual toward manifestation of male somatic characters as Doctor Meigs has pointed out. The granulosa cell tumors, however, may cause enlargement of the uterus, endometrial hyperplasia, and uterine bleeding either in young children or in adults past the menopause—certainly a modification toward femaleness.

This leads us naturally to a biologic consideration of sex determination. The geneticists have told us in the past that sex is determined by the genic composition of the chromosomes at the time of fertilization. This mechanism still seems to hold for certain forms but for the higher vertebrates the sex glands remain in an undifferentiated stage until influenced by hormones. The anterior hypophysis secretes a gonadotrophic factor which has the power to arouse the dormant sex cells toward differentiation either to maleness or femaleness. The male or female sex hormones formed by the differentiated gonads cause the complete differentiation of the secondary sexual apparatus. Thus, when the ovary starts to develop following hypophyseal stimulation, the wolffian ducts drop out and the müllerian ducts hypertrophy to complete the female sexual apparatus. Certainly under conditions of experimentation

with the sex hormones, the primary germ cells of a given embryo can be made to differentiate either toward maleness, femaleness, or both. This would seem to indicate that the primitive sex cords are potentially hermaphroditic in their ability to respond to either sex hormone.

It is now generally accepted by biologists that there is no antagonistic action between the sex hormones. Each sex hormone is regarded as specific for its own differentiated tissues. But in the normal individual one kind of sex hormone dominates and part of the primitive sex cells remain undifferentiated, acting like a rudimentary structure. In the female ovary the medullary portion contains apparently functionless sex cells which persist from the undifferentiated stage. In the testis there is no corresponding remnant of the primitive sex cells. Consequently, the female always has present a structure which under proper stimulation may differentiate toward maleness.

It may be that the explanation of the trend toward maleness exhibited by certain of the ovarian tumors comes about through a certain amount of dedifferentiation of the cells of the ovary which is necessary in order to have a neoplastic growth. It is well known that tumor growth takes place in undifferentiated or in dedifferentiated tissues. Factors which produce differentiation in general tend to restrict growth. The dedifferentiation of the ovary would tend to remove the conditioning sex hormone and to allow the rudimentary sex cords to assume the male type. There is ample experimental evidence to show that if the female conditioning factors are removed at certain stages the undifferentiated sex cords tend toward maleness (twinning in cattle, castration of ovaries in hens, *etc.*).

The sex hormones—oestrogenic substances—have a peculiar significance in that they are closely related chemically and in their biologic behavior to some of the carcinogenic agents which have been isolated from coal tar. And conversely, some of the carcinogenic agents from coal tar have been shown to have oestrogenic powers biologically on test animals.

The effect of oestrogenic substances on the somatic cells if long enough continued may be to produce hypertrophy or neoplastic growth. This has been demonstrated in animal experimentations. The female sex hormones can cause changes in the uterus, vagina, mammary glands, *etc.* The male sex hormone can cause changes in the prostate, and accessory spermatic ducts. The tissue changes produced by the oestrogenic substances in causing neoplasms differ in one important respect from those produced by the carcinogenic substances recovered from coal tar. The oestrogenic substances produce malignant change only in specific tissues; whereas the carcinogenic agents produce changes in any tissue. The time factor necessary for the production of malignant change is common to both oestrogenic and carcinogenic agents.

DR. JOE V. MEIGS (Boston, Mass.).—There is one thing I would like to say. If you consider the dysgerminoma or seminoma of the ovary which causes maldevelopment in the female a teratoma, which it is, and if you consider a teratoma as a twin of its host, which it may be; then as the tumor is dominantly male the patient should be a free martin or a neutral, which one patient in our series was.

CHOICE OF METHODS OF DIVERTING THE URINARY STREAM ABOVE THE LEVEL OF THE BLADDER

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IN THE subsequent discussion it will be assumed that for some one of a variety of reasons the bladder has become for practical purposes either worthless, dangerous, or both.

CONDITIONS FOR WHICH DIVERSION MAY BE NECESSARY

1. *Congenital Anomalies.*—In this group the most outstanding is exstrophy of the bladder in regard to which it may be safely asserted that no plastic operation having for its purpose the construction of an anterior vesical wall and the development of a sphincter has proved satisfactory. For this reason diversion of the urinary stream with removal of the exstrophic bladder is universally agreed upon. Closely allied to this condition is the severe grade of epispadias. This may be defined as a situation in which the superior wall of the urethra is missing together with the sphincter mechanism of the bladder neck. It is probably conservative to suggest that in many or most of these cases an attempt should be made to construct a vesical sphincter and a urethra. This can probably be undertaken without serious danger of infection of the upper urinary tract, although this is an ever present possibility as a sequel of operations for reconstruction of the vesical outlet. In a certain proportion of these cases, apparently from the literature in a considerable proportion, plastic operations will fail to give a satisfactorily continent bladder and the condition must then be dealt with as in exstrophy. Third in this group comes a still undefined group of cases in which there is apparently some congenital defect in the nerve mechanism controlling the musculature of the urinary tract. The commonest clinical picture is the association of incomplete retention of urine and a constant large residual urine with dilatation of the ureters and kidney pelves and often extensive damage to the renal parenchyma. This is today commonly detected in childhood as the result of difficulties in urination or when an incurable pyuria leads to further investigation. With this situation is often associated varying degrees of spina bifida, whether of the occult or the sacculated type. In some instances complete incontinence will be found, associated, however, with functional obstruction of the ureters, apparently from lack of contractility of the muscular structures. The diagnosis is not always simple, since a variety of congenital obstructions at the bladder neck, which

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include valves and other congenital deformities, may give rise to a similar clinical picture, but are remediable by correction of the bladder neck obstruction. Only those cases should be regarded as due to anomalies of the nerve supply in which careful study of the bladder neck quite fails to show any of the anomalies above referred to. As these patients have been seen in the past, their outlook was very hopeless, since satisfactory emptying of the urinary tract could not be obtained, and drainage of the bladder commonly is quite impotent to relieve the stasis in kidney and ureter. It has been suggested that operation upon the sympathetic nerve mechanism, possibly upon the presacral nerve, may be of value to some of these patients. In regard to this one can only say that to date few if any thoroughly satisfactory results have been published. Assuming that remedy of the condition cannot be obtained by dealing with lesions of the bladder neck, and further assuming that operation upon the sympathetic mechanism is not thought desirable, the integrity of the kidneys can be preserved—perhaps over a long period of time—by diversion of the urine above the level of the bladder. They, therefore, come into this category.

2. *Injury to Bladder or Ureters.*—A second important, though not very numerous, group is that with injuries of the bladder or ureters. In this group will be found a small number of cases of unusually large vesicovaginal fistulae, often in patients in whom several attempts at operative cure have failed. When the stage is reached at which there is insufficient tissue with which to construct a satisfactory bladder floor, then diversion of the urinary stream above that level must be entertained.

Injury of one or both ureters occasionally occurs in connection with pelvic operations, most commonly for cancer. In a proportion of these cases it may be possible to immediately suture the divided ureter if the ends can be approximated without tension. In another moiety the ureter can be reimplanted in the bladder, which, under favorable circumstances and with good technic, is preferable to any operation for diversion. Not uncommonly, however, the injury of the ureter may not be detected or the actual solution of its continuity may not occur until some days after operation. At this time suturing of the ureter will be found considerably more difficult, and reimplantation into the bladder not only more difficult, but associated with a not inconsiderable risk from infection due to a secondary operation in a recently traumatized field. In those cases in which reconstruction of the ureter is impossible, and reimplantation cannot be safely undertaken, diversion above the level of the bladder is indicated.

3. *Non-Tuberculous Chronic Cystitis.*—Third is a not large but important group of cases which will be of inflammatory—non-tuberculous—origin. Although these conditions are described by a variety of names, among others the “elusive ulcer,” they are, we believe, all cases of extensive chronic interstitial cystitis. In a considerable number of such cases, at least, the cause is obscure, though in some of them they are the direct result of prolonged infection, perhaps associated with prolonged drainage of the bladder. For those

cases in this group in which contraction of the bladder has gone on to such a point that its capacity is very seriously impaired and in which local treatment combined with periodic overdistention fails to relieve, diversion of the urinary stream above the bladder becomes the method of election.

4. *Tuberculosis*.—This group includes cases of tuberculous cystitis, almost invariably secondary to renal tuberculosis. They may be cases in which at the outset the diagnosis of unilateral surgical tuberculosis was satisfactorily made and nephrectomy done. Sometimes the tuberculous cystitis never subsides to an extent to allow of reasonable comfort. More commonly there is a period, sometimes for some years, of partial or extensive relief, to be followed by a recrudescence of the cystitis, perhaps associated with development of tuberculosis in the remaining kidney, but sometimes, at least, in the presence of a still uninfected kidney. In this group should also be included a small number of cases in which tuberculous urethritis with the development of multiple fistulae has rendered the patient's condition intolerable. The group of cases which may be considered suitable for diversion of the urinary stream are those in which the bladder condition is intolerable. Urinary frequency, and perhaps strangury, veto anything approaching comfortable existence, and the patient is condemned to torture during his remaining days. These patients may from the outset have a bilateral renal tuberculosis, but in any case many of them will live in torture for years, and are entitled to the relief which can be obtained by diversion of the urine. In this group of cases and in the preceding one, bladder drainage by suprapubic cystostomy fails to give satisfactory relief. It is further important to remember that the ureter of the remaining kidney when nephrectomy has been performed for tuberculosis is frequently abnormal, often showing considerable dilatation, apparently due to the increased thickness of the bladder wall through hypertrophy produced by frequency of urination. Obviously for this condition cystostomy will not be satisfactory.

5. *Cancer of the Bladder*.—Finally, one comes to the relatively large group of cases of cancer of the bladder in which the growth encroaches or certainly will encroach upon one or both ureters, and in which even the satisfactory removal or destruction of the tumor will still fail to relieve the patient. For some of these situations in which resection of the bladder wall is thought desirable, reimplantation of the ureter offers a satisfactory solution. In a not inconsiderable group, however, it is becoming increasingly apparent that nothing short of total cystectomy is at all likely to result in cure, and to the extent that we can with reasonable safety and reasonable comfort divert the urinary stream, to that extent the feasibility of total cystectomy will be increased. It is not intended here to discuss the very complicated problem of treatment of the more malignant bladder tumors. It is only suggested that there is wide agreement that for a considerable number, and perhaps for an increasing proportion, diversion of the urinary stream, with or without total cystectomy, is indicated.

METHODS OF DIVERTING THE URINE ABOVE THE LEVEL OF THE BLADDER

Having thus indicated the field for which diversion will be valuable, we must next turn to the methods at our disposal. At the present time they are three. We may divert the urine at the level of the kidney—nephrostomy. We may divert the urine by implantation of the ureter into the large intestine—uretero-enterostomy. We may bring the ureter out to the surface of the abdomen—cutaneous ureterostomy.

ADVANTAGES AND DISADVANTAGES OF THESE METHODS

1. *Nephrostomy*.—Since we believe that nephrostomy for anything but very temporary diversion is to be preferred to pyelostomy, this latter method is not here discussed. Nephrostomy diverts the urine at the level of the kidney. It has the advantage over all other methods in that it does not involve the division of the ureter, and does not, so to speak, burn one's bridges. It may therefore be employed as an intermediate stage, when, owing to the patient's condition, such as the recent proximity of a serious abdominal operation, no rearrangement of the ureter can properly be undertaken. It may be undertaken deliberately in the presence of damaged ureters in order to improve the condition of the kidneys, and perchance of the ureters, so as to make some further operation upon those structures reasonably safe. Properly done nephrostomy provides excellent drainage, though if the ureter be still patent, as will be the case as a rule, it does not entirely divert the urinary stream in most cases. It is an operation which can be relatively rapidly done, and with a relatively low mortality. If it is contemplated to make the diversion permanent, nephrostomy is a somewhat inconvenient arrangement for the patient, and, though he may learn to care for himself in a reasonably satisfactory manner, such is not always the case. Probably the greatest claim of nephrostomy is as a temporary measure, though if the measures contemplated for relief of the condition of the ureter should fail, it can always, so to speak, be made permanent. The mortality from the operation itself is difficult to state in precise terms, since it is intimately involved with the condition of the kidneys upon which the nephrostomy is undertaken. In and of itself it can be quickly and easily done, and should not involve a mortality of more than 5 per cent.

2. *Entero-Anastomosis*.—This is a method which has gained rapidly in favor since the technic suggested by Coffey,⁶ of oblique introduction of the ureter into the bowel, has been generally used. The previous methods of which the Stiles¹⁸ operation was perhaps the best example appear in the light of developments of the last ten years to involve a higher mortality, greater severity of renal infection, and a less permanently satisfactory condition of the patient.

In the following discussion we shall therefore assume that the principle of oblique implantation advocated by Coffey³ is the method of election, though there are a variety of technics, some of which at least are too recent to warrant satisfactory appraisal. At the outset it should be recognized that entero-

anastomosis involves the division of the ureter, and its permanent disconnection from the bladder. To this extent it is more radical than nephrostomy. It is next important to appreciate that the operation is technically difficult and requires familiarity with the surgery of the urinary, as well as the intestinal, tract. The outstanding danger is that of infection, whether immediately, in connection with the operation (a risk which has been steadily diminishing with improved technic), or at various subsequent periods due to an ascending ureteritis and pyelonephritis which in the past has often been subject to periodic exacerbations.

It is perhaps proper here briefly to examine the claim put forward by Coffey³ and others as to the method by which this oblique transplantation produced its results. It is not, we believe, anywhere suggested that there is

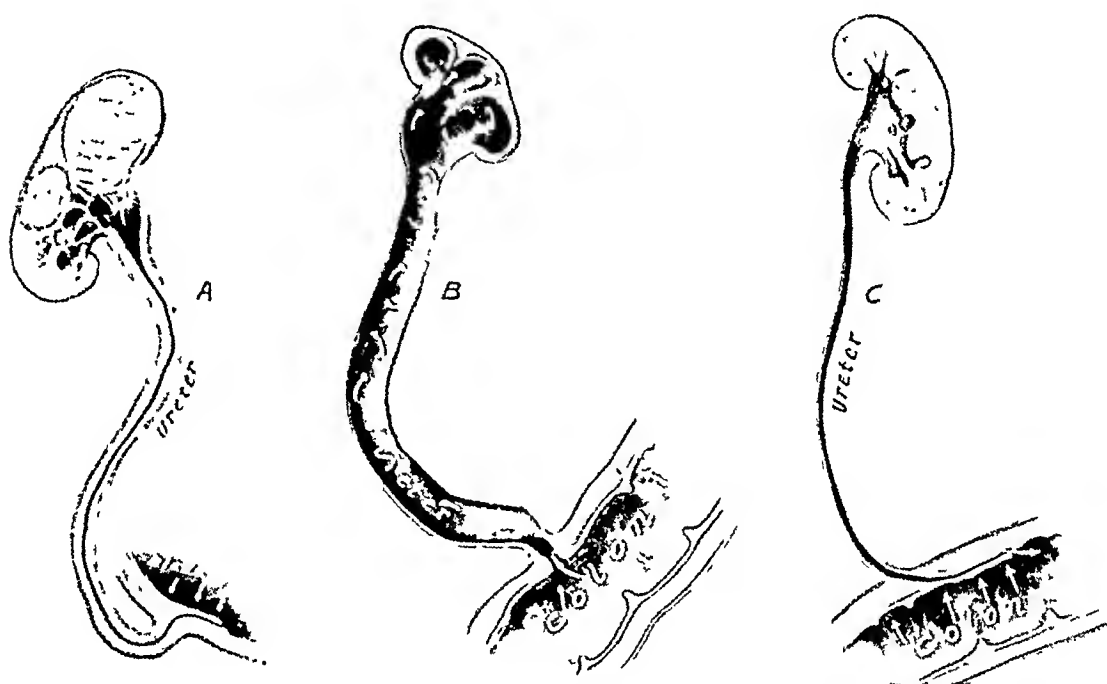


FIG. 1.—The *modus operandi* of so called "ascending infection." (A) What probably happens in experiments wherein infectious material is injected around the ureter near the bladder, true ascending infection following the lymphatic streamlines. (B) Dead kidney; dilated ureter following direct implantation of the ureter into the colon. This result usually has been referred to as "ascending infection." It is more probable that the kidney has been destroyed and the ureter dilated by static intra-intestinal pressure applied inside the ureter. (C) Normal kidney and undilated ureter which follow submucous or indirect implantation of the ureter into the colon (after Coffey).

created by this method anything which resembles the sphincteric mechanism of the ureterovesical orifice. Coffey⁴ in his earlier papers described and illustrated his theory that the closure of the ureter in its oblique course through the bowel wall was effected by distention of the bowel, and that there was thus avoided the gaping orifice which had probably been associated with the direct methods of transplantation. He suggested that there was created here a valve which was closed by any condition tending to produce distention of that portion of the gut into which the ureter had been introduced (Fig. 1). It is difficult for us to appreciate how any such action can take place. A distention of the bowel sufficient to close the orifice would seem to us unlikely

to exist during most of the time. On the other hand, there is no force which tends to create back pressure upon the opening into the intestine, since it is unlikely that the accumulation of urine in the rectum will be sufficient to put the bowel wall on a stretch to any serious degree. Whatever may be the mechanism, it seems quite certain that our results as regards infection of the upper urinary tract to a serious or fatal degree have rapidly diminished since the introduction of this technic.

More recently a variety of methods have been suggested following the third type of operation suggested by Coffey⁷ in which he did not produce immediate communication between the ureter and the intestine, but, by the introduction of a suture through the wall of the ureter and the mucous membrane of the intestine, allowed this to develop in the course of a few days as the suture cut through. At the time of his death, we believe, he advised the use of this technic for one ureter, leaving the other in open communication with the bowel by means of the catheter which he regularly employed. This suggestion of Coffey's⁷ has been followed up by other writers, notably Higgins,⁸ Zollinger,²⁰ and Poth.¹⁵ The purpose of these alterations in technic is to avoid the infection which it is believed inevitably takes place from the exposure of the cut end of the ureter to the infected interior of the bowel. Most of the work, including that of Coffey, is either experimental or includes only a relatively small number of patients—too few to warrant safe conclusions. Clearly a considerable period of time should elapse before we can safely assume that these methods of what might be called the two stage anastomosis with the intestine do not involve the creation of an amount of scar tissue around the opening which at a subsequent period will contract and produce stricture. Such an eventuality is to be feared from what we know of the tendency of small openings in the side of the ureter to undergo some measure of closure. Only the lapse of some years can safely determine this point. Moreover, we are by no means clear that any of these methods do in fact insure to a high degree against ascending infection. We have progressively come to the view that ascending infection takes place by continuity along the ureter and does not take place along the periureteral lymphatic trunks which are segmental and not continuous. It is not clear to us that the slow cutting through of a ligature or similar method will in fact completely close the tissues of the ureter and insure against ascending infection. In fact this seems to us relatively unlikely, and we have seen no convincing evidence that implantation of the ureter into the large intestine by any method entirely and permanently avoids infection by the ascending route. That the infection is, by the use of modern methods, very much less than it used to be, that in a handsome proportion of cases it is trivial, and that adjustment to it takes place, seems to us quite clear. There are now at our disposal a considerable group of patients in whom the general principles of the Coffey technic have been used in which the operation was done more than 15 years ago. It is beyond question that the condition of these patients is enormously superior to that which we used to see following previous methods, but we do not think

we can safely assume that the kidneys of these patients are wholly free from infection and will remain so.

Another not inconsiderable objection, though one which in our judgment does not at all invalidate the usefulness of the procedure is the entire inaccessibility of the ureter once the implantation has been done and the catheters, if such have been used, have come away. Should serious infection supervene, or should obstruction slowly occur with the development of hydronephrosis, and its sequel pyonephrosis, our hands are tied as far as relieving the condition through the ureter is concerned. We may of course resort to nephrostomy if the situation warrants it, but at best we are in a weak position if these unfavorable developments occur.

Against these qualifications and difficulties must be placed the fact that satisfactory entero-anastomosis having been carried out, the patient is dry, clean, and comfortable. Furthermore, as already pointed out, there is accumulating evidence that these patients go on in comfort with kidneys, which if not sound, are at least sound enough for practical purposes for a period of many years. There can be no doubt that in properly selected cases, and in capable hands, uretero-enterostomy is an operation of first class importance.

We have postponed any discussion of the mortality because it is so difficult to give any clear and useful statement. Few very large series of comparable cases have been reported, and the conditions for which the operation was undertaken vary through a wide range. The selection of cases has been made very variously by different surgeons and in different countries, all of which makes any clear statement as to the risk verge on the impossible. It is curious, but apparently true, that of the cases reported in Europe the mortality in considerable groups is importantly higher than in the groups reported in this country. Thus Smitten¹⁷ collected 316 cases of uretero-enterostomy in Europe with a mortality of 36.87 per cent. In the group of cases in which the transplantation was done for cancer, the mortality was 63.8 per cent. Papin¹³ collected a series of 81 cases of uretero-enterostomy for cancer of the bladder with a mortality of 59.2 per cent. With this may be compared a group of 66 cases reported from The Mayo Clinic with a mortality of 16.6 per cent, and a subsequent report from the same clinic by Walters¹⁹ of 76 cases with a mortality of 3.9 per cent. In these cases from The Mayo Clinic few if any cases of cancer of the bladder were treated by this method. Coffey⁶ reported 18 cases of non-malignant conditions with a mortality of 11 per cent, and 17 cases of cancer with a mortality of 29.4 per cent. Nitch¹² reports six cases of non-malignant conditions with a mortality of 16.6 per cent and 14 cases of cancer with a mortality of 64.3 per cent. This perhaps gives as fair a picture as can be obtained in this complicated field. It at once appears that entero-anastomosis undertaken for cancer of the bladder has everywhere shown a mortality greatly in excess of that which follows its use in non-malignant conditions.

Cutaneous Ureterostomy.—This operation was first undertaken a good many years ago. It was apparently first proposed by Gigon⁷ in 1856, and

first carried out shortly thereafter by LeDentu.¹⁰ Like uretero-enterostomy it involves complete separation of the ureter from the bladder, and to this extent is permanent. It is technically an easy operation as compared with uretero-enterostomy, and the drainage is good if properly managed. The danger of infection is probably not greater than that involved in intestinal anastomosis, and should a severe infection occur, the ureter is accessible for irrigation and drainage. It is particularly applicable to the abnormal ureter. In fact, the grossly abnormal ureter is more easily managed by this technic than the normal one. Opposed to these desirable characteristics is the fact that the patient is required to wear an apparatus for reception of the urine, and has to take care of a small, though always present, dressing. It is not true, as has been commonly supposed, that these patients cannot be kept dry, and are consequently more or less malodorous. With good technic and proper management, an entirely dry, clean diversion can be had, and the patients may lead normal lives without social embarrassment.

In 1913, Schichkoff¹⁶ was able to collect 43 cases of cutaneous ureterostomy. Twenty unilateral cases showed a mortality of 10 per cent. Twenty-three bilateral cases showed a mortality of 26 per cent. The bilateral cases were all cases of cancer which perhaps explains the mortality. Papin¹⁴ reported a series of 96 cases of his own and other surgeons in which operation was done for malignant tumors, tuberculosis, and malformations of the bladder with a mortality of 24.9 per cent.

The operation seems to have been done more commonly in Europe than in this country, perhaps because of the above suggested high mortality of uretero-enterostomy. The question of the duration of life after cutaneous ureterostomy is difficult to state. The majority of patients for whom it has been done have been subjects either of cancer or tuberculosis. Now obviously either of these diseases is likely to kill the patient within the next ten years, although in the case of the patient with a non-tuberculous remaining kidney and an intolerable tuberculous cystitis, survival may take place for many years. Keyes⁹ recently reports one of more than ten years. The cases thought suitable for cutaneous ureterostomy will as a rule have damaged ureters and more or less damaged kidneys. This situation cannot be compared satisfactorily with the patients for whom uretero-intestinal anastomosis is undertaken, since they should in the majority of cases have normal ureters and normal kidneys. One group starts from scratch with a normal urinary apparatus above the bladder, the other starts with a tremendous handicap of disease which in the case of cancer and tuberculosis will in the normal course of events be fatal in any case. To this extent the expectancy of life as concerns the two operations is difficult to compare.

CHOICE OF OPERATIONS AND TECHNIC

Nephrostomy.—To summarize what has above been said—nephrostomy is perhaps at its best as a temporary expedient to bridge the gap so that a more permanent arrangement such as reimplantation of the ureter into the

bladder, possibly uretero-ureteral anastomosis or uretero-intestinal anastomosis may be carried out. It will thus be useful in the case of ureters injured at an operation in which the condition of the patient does not justify further prolonging it or in which the injury to the ureter is not discovered until subsequent days. It will be useful in ureterovaginal fistulae developing at some distance following a pelvic operation, as for instance, hysterectomy, either for malignant or benign tumor. The same applies to various other operations in the pelvis in which injury to the ureter occasionally takes place. Its chief function is in making postponement of the final adjustment of the urinary tract possible. In regard to technic, the method suggested by us in conjunction with our colleague, W. W. Holland,² in 1932, has stood us in good stead. It can be carried out without extensive mobilization of the kidney, it avoids unnecessary damage to the kidney, and prevents the traumatic bleeding which has in the past blocked tubes and caused annoyance.

Uretero-Enterostomy.—The most favorable group of cases are those in children with exstrophy or epispadias in which the ureters are normal. For these patients with the appropriate technic, I believe that the operative mortality should be well below 5 per cent. The next most favorable group will be in those patients in whom the bladder is seriously involved, but in which the ureters have remained normal. This will include chiefly the patients in Group 2 above referred to—that is to say those with vesicovaginal fistulae, and in Group 3, those with non-tuberculous chronic interstitial cystitis. Here if the ureters are normal and the operation well executed, a low mortality can be expected. Patients with cancer present a difficult problem. In the earlier stages, even with growths situated, as they most commonly are, in the base of the bladder, there may be no involvement of either ureter. To this extent the conditions for uretero-enterostomy are favorable. On the other hand, it is at least desirable to subject these patients to as few operative procedures as possible. For this reason both ureters must be moved at the same sitting, and it is eminently desirable that the bladder should be removed at the same time. This is a formidable procedure and will test the skill and dexterity of the surgeon as well as the resisting powers of the patient. Most of them are old. The presence of cancer seems in some mysterious way to lower their vitality, and we fear that the mortality will long remain higher than among those patients with normal ureters but without cancer. The first principle exemplified by the low mortality in children and in adults with non-malignant bladder lesions is that the implantation of a normal ureter is not a severe proceeding. The next principle is that simultaneous bilateral transplantation is importantly more risky than if one ureter is moved at a time. The lowest mortality can be obtained by doing the operation in two stages and making the operation substantially extraperitoneal, as in the operation first described by C. H. Mayo, which one of us (Cabot¹) has consistently employed for such cases for 15 years and in which the mortality should not exceed 3 per cent. This method is feasible and desirable in most of the patients without cancer,

but in the presence of cancer subjects the patient to a multiplicity of operations which may well turn the scale against him.

When one comes to consider the implantation of abnormal ureters, the case is very different. Given gross abnormality with dilatation and hypertrophy of the ureter, entero-anastomosis takes on a risk which in our experience has rarely been justified. Now it is occasionally possible to minimize this risk by combining nephrostomy for kidney drainage with a subsequent uretero-enterostomy carried out during diversion of the urinary stream at the kidney level. Done in this way we have been able successfully to transplant five ureters in three patients without mortality. It is probably applicable chiefly to those patients in whom there has been accidental injury to the ureter and for whom uretero-ureterostomy or ureterovesical implantation are unsuitable. For them nephrostomy and subsequent uretero-enterostomy may be the method of choice. With this exception it seems that experience at least suggests that the grossly abnormal ureter is rarely suitable to this method of management.

Summarized, the transplantation of the normal ureter carries a relatively low mortality. If the operation can be done in two sittings, as is suitable for exstrophy, epispadias, vesicovaginal fistula, chronic interstitial cystitis with normal ureters, a very low mortality can be expected. Bilateral simultaneous transplantation will always give a somewhat greater risk, but in good hands and with normal ureters, is a satisfactory procedure.

Cutaneous Ureterostomy.—This appears the method of election for the great majority of cases with grossly abnormal ureters. It is quite certainly the method of election for patients with vesical tuberculosis of an intolerable and intractable type, whether the kidney lesion be a bilateral, inoperable tuberculosis, tuberculosis of a remaining kidney after nephrectomy, or as not rarely occurs, in the presence of an intractable bladder lesion but with a remaining kidney normal except for some dilatation and atony of the ureter. For these patients immense relief may be expected. The duration of life will of course depend upon the condition of the kidneys as concerns infection with tuberculosis.

For patients with cancer in whom total cystectomy is considered or in whom the bladder lesion has involved one or both ureter orifices and is endangering kidney function, cutaneous ureterostomy seems the method of choice. It is a relatively easy operation with low mortality. It can safely be combined with total cystectomy if the situation is favorable. It can be done as a preliminary to total cystectomy without complicating the approach to the bladder, and the cystectomy can be undertaken relatively shortly after the diversion of the urinary stream.

In regard to the technic, we think it important that the ureter should be made to lead straight from kidney pelvis to point of exit in the skin (Fig. 2). We believe it desirable to bring the ureter out at a point considerably higher than is commonly employed, namely at about the level of the anterior iliac spine. Done in this way the blood supply of the ureter is better and there is less ureter involved. We think it important to free the ureter in such a

DIVERSION OF URINE ABOVE BLADDER

way that it will project for some distance beyond the skin after the wound is closed, and that the ureter should not be attached to any of the underlying tissues for fear of injury to the ureter with the development of scar and fistula (Fig. 3). Dry, comfortable diversion can be best obtained by keeping a catheter of appropriate size permanently in the ureter, its point lying com-

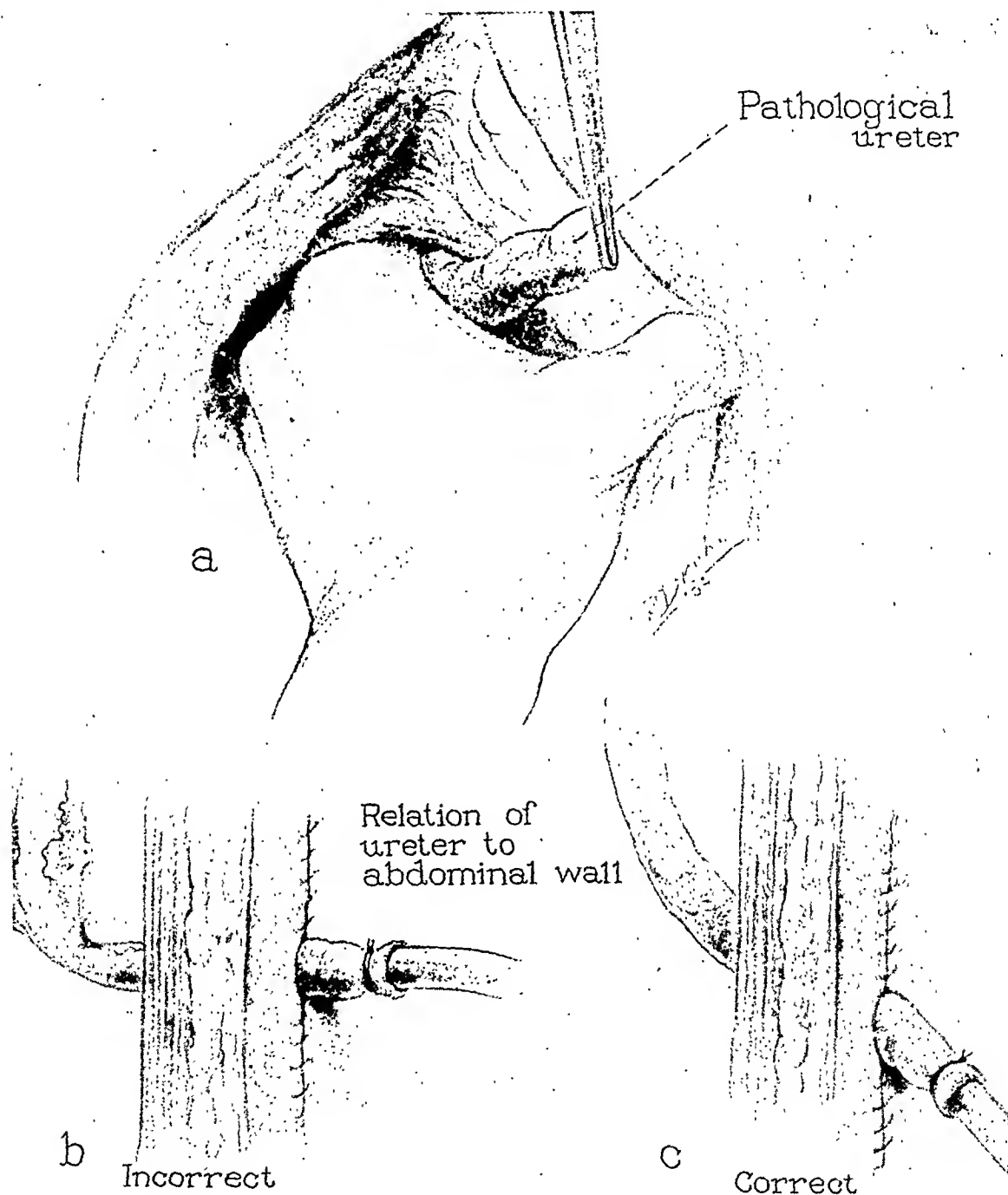


FIG. 2.—These drawings illustrate two important points: (1) (a) shows the freeing of the ureter upward toward the kidney in order to eliminate kinks and twists which are so commonly present; (2) (b) and (c) illustrate the incorrect and correct methods of bringing the ureter through the tissues of the abdominal wall.

fortably within the renal pelvis. In this way dryness can be achieved, which is very difficult by the employment of any form of apparatus or cup designed to fit snugly over the orifice. Moreover, the constant presence of a catheter in the ureter will avoid the development of stricture, which is liable to occur at the point of exit from the skin (Fig. 4). This complication can, we think,



FIG. 4.—Shows the appearance of the grossly abnormal ureter which is commonly to be dealt with in this operation. The insert, upper left, shows the position of the incision.

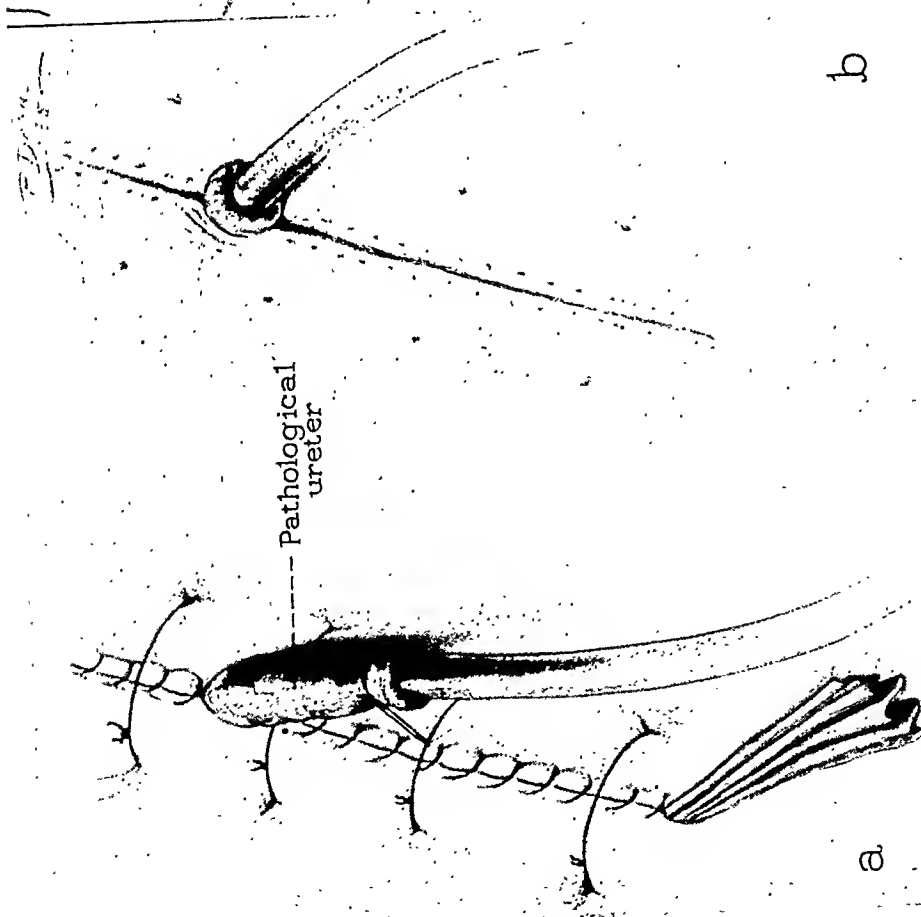


FIG. 3.—(a) Shows the method of holding the tube in the ureter by a tie placed about it, and the avoidance of attachment of the ureter to the skin. If there is danger of tension, the ureter may be attached indirectly to one of the sutures, closing the abdominal wound. (b) Shows the condition of the stump of the ureter ten days after ureterostomy. It illustrates the level at which sloughing takes place and the way in which the mucous membrane of the ureter everts so as to prevent stricture.

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often be avoided by the method of leaving the ureter projecting beyond the skin at the time of operation, and allowing it to slough off, which it will ordinarily do, leaving a pouting rosette of mucous membrane which guards



FIG. 5.—Illustrates the type of apparatus actually used by a patient with a single remaining kidney 18 months after ureterostomy for intractable vesical tuberculosis.

the orifice. The catheters thus employed may be led either into small hot water bottles suspended from a belt or to the long narrow rubber urinals which have been employed in the past for patients with incontinence (Fig. 5).

If reasonable care is taken in regard to cleanliness of the rubber receptacles, complete absence of disagreeable odor can be assured.

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DIVISION OF THE SPERMATIC CORD AS AN AID IN OPERATING ON SELECTED TYPES OF INGUINAL HERNIA

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COMPLETE division of all the structures comprising the spermatic cord, as an aid in the cure of certain types of inguinal hernia, appears to be a most radical procedure. Orchidectomy has been resorted to occasionally to eliminate the weak spot caused by the emergence of the cord in multiple recurrences; and it occurred to us that if we could divide the cord without causing subsequent sloughing of the testicle, the operation would be expedited and a more perfect repair obtained. We had observed patients in whom, at operation, the vessels had been practically destroyed without necrosis of the gland; and we finally decided to divide the cord deliberately, and were gratified to find that the testicle did not slough.

The following indications, in our opinion, justify this radical procedure:

(1) Recurrent herniae which have had one or more unsuccessful attempts at a radical cure in individuals past 50 in whom the opposite testicle is apparently normal.

(2) Recurrent herniae in younger subjects who are incapacitated from their usual occupation, and who have an apparently normal testicle on the opposite side. These patients have usually had more than one attempt made at a repair; and if, at operation, division of the cord offers a more favorable prognosis, we do not hesitate to divide it.

(3) Large scrotal herniae in the aged, which are either irreducible or cannot be satisfactorily retained by a truss.

(4) Large sliding herniae.

Division and resection of a part of the cord reduce the operating time at least a third. Furthermore, it permits two layers of muscle or fascia to be sutured to Poupart's ligament without any intervening tissue, and without leaving a weak spot in either layer which of necessity exists if the cord is present.

In order to obtain the maximum benefit in time-saving, the cord must be divided early in the operation. We make our decision as soon as the sac has been isolated. A ligature is placed about the cord at its emergence through the internal ring, and a second one as it enters the scrotum, the intervening tissue being excised. The collateral circulation is limited and we believe that the lymphatic supply must aid in nourishing the gland until the arterial supply is sufficiently reestablished. In scrotal herniae it is unwise to disturb the lower end of the sac for fear of damaging the future collateral circulation; and we make it a practice never to deliver the testicle into the wound or to remove the scrotal portion of the sac.

ANALYSIS OF CASES OF DIVISION OF THE CORD IN THE REPAIR OF INGUINAL HERNIA

No.	Age	Diagnosis	Operation	Date	Wound Healing	Followed	Hernia Wound	Testicle	Remarks
1	FK 62	ROIH scrotal	Gallie	1/17/28	P.U.	12/11/29	O.K.		Induration of scrotum for five months
2	AG 67	ROIH scrotal	Gallie	11/ 2/28	P.U.	12/ 3/28	O.K.		Died third day, pneumonia
3	JW 65	RDIH recurrent	Gallie	11/22/28	P.U.	11/25/28			
4	MM 43	RDIH recurrent	Gallie	1/15/29	P.U.	10/21/29	O.K.		
5	AM 59	LOIH sliding	Ox fascia	3/ 5/29	Slight serous drainage	4/12/29	O.K.		
6	GS 79	ROIH	Ox fascia	3/ 7/29	P.U.	7/ 8/34	O.K.	Slight atrophy	
7	GS	LOIH	Ox fascia	3/ 7/29	P.U.	7/ 8/34	O.K.	Slight atrophy	
8	HJ 45	LOIH sliding	Ox fascia	3/14/29	P.U.	4/ 5/29	O.K.		
9	AR 58	ROIH recurrent	Ox fascia	3/19/29	P.U.	10/ 3/30	O.K.	Normal	
10	WV 30	ROIH recurrent	Gallie	4/23/29	P.U.	9/12/32	O.K.		
11	SS 55	ROIH incarcerated	Ox fascia	5/ 9/29	P.U.	5/27/29	O.K.		Slight swelling of scrotum
12	WD 64	RDIH recurrent	Ox fascia	6/26/29	Drained at operation. Healed in one month	9/23/29	O.K.		
13	JK 60	LOIH scrotal	Ox fascia	9/ 3/29	P.U.	11/17/31	O.K.	Atrophied	
14	JP 65	ROIH	Ox fascia	9/10/29	P.U.	11/16/31	O.K.		Induration of scrotum for two months
15	ES 49	ROIH scrotal irreducible	Gallie	9/30/29	P.U.	12/ 2/31	O.K.		
16	RG 41	LDIH recurrent	Ox fascia	10/ 8/29	P.U.				
17	FA 65	ROIH scrotal	Gallie	10/22/29	P.U.	2/26/30	O.K.		
18	HG 39	ROIH scrotal irreducible	Gallie	12/ 3/29	P.U.	1/ 3/30	O.K.		
19	JR 67	RDIH recurrent	Ox fascia	12/10/29	Mild infection	2/26/32	Recurrence	One-half normal	
20	PH 52	LOIH sliding	Gallie	12/10/29	P.U.	12/12/34	O.K.	Normal	
21	JC 58	ROIH recurrent	Gallie	12/10/29	P.U.	12/12/34	O.K.	Normal	
22	UA 55	RDIH recurrent	Gallie	12/17/29	P.U.	1/15/30	O.K.		
23	PL 44	RDIH	Gallie	12/27/29	P.U.	2/24/30	O.K.		
24	MF 57	LDIH	Gallie	1/ 7/30	P.U.	6/20/30	O.K.		
25	AL 56	LOIH recurrent	Ox fascia	2/11/30	Mild infection	3/ 1/35	O.K.		3/10/35 same
26	MH 45	RDIH recurrent	Ox fascia	2/18/30	Infected 18 days	9/11/31	Recurrence	Normal	8/11/31 same
27	EW 73	RDIH recurrent	Gallie	3/18/30	P.U.	3/25/30	Recurrence		Died third day, pneumonia
28	GB 59	LOIH sliding	B	6/ 3/30	P.U.	3/21/30			Small hydrocele
29	RW 55	ROIH sliding	Gallie	6/17/30	P.U.	12/10/34	O.K.	Normal	Marked swelling of scrotum
30	JC 68	ROIH scrotal	B	7/15/30	P.U.	7/ 9/30	O.K.		
31	PF 52	RDIH recurrent	Gallie	7/15/30	P.U.	9/26/30	O.K.		
32	EP 50	ROIH	Gallie	7/20/30	P.U.				
33	FC 50	LOIH scrotal irreducible	Gallie	7/20/30	Infected three weeks	12/ 9/31	O.K.		Died of pneumonia, three and one-half years
34	PS 65	ROIH scrotal	B	8/12/30	Late infection. Healed after suture sloughed	2/ 1/34	O.K.		

SPERMATIC CORD SECTION IN HERNIOTOMY

34	JH	59	LOIH scrotal recurrent	Ox fascia	8/10/30	P.U.	5/13/31	O.K.	Normal	
35	CR	55	RDIH strangulated	Ox fascia	9/13/30	Mild infection	11/17/31	O.K.	Normal	
36	CR	54	LDIH scrotal	Ox fascia	9/30/30	Slight infection	11/17/31	O.K.	Normal	
36	JC	54	LOIH	Ox fascia	9/16/30	Hematoma of scrotum, drained seventh day	2/25/31	Recurrence		Reoperated 10/13/31
37	JD	76	RDIH scrotal	Ox fascia	9/23/30	Hematoma of wound, drained seventh day	10/11/34	O.K.	Normal	
38	MP	40	ROIH	Gallie	9/23/30	P.U.	12/ 4/31	O.K.		
39	CQ	63	ROIH scrotal	Ox fascia	9/25/30	Slight infection	10/11/34	O.K.		
40	PV	45	RDIH recurrent	Gallie	10/14/30	P.U.	2/ 8/31	Recurrence		10/14/34 same
41	LT	66	ROIH	Gallie	11/11/30	P.U.	2/20/33	O.K.		
42	JS	34	RDIH recurrent	Gallie	11/23/30	Postoperative hemorrhage, packed	2/ 9/34	O.K.		
43	FP	58	RDIH recurrent sliding	Gallie	12/ 2/30	P.U.	12/26/30	O.K.		
44	HS	80	ROIH scrotal	B	12/18/30	Deep abscess	12/29/30			Died 11th day, peritonitis
45	MS	39	LOIH incarcerated	Ox fascia	1/27/31	P.U.				
46	JH	58	ROIH	Ox fascia	2/17/31	P.U.	11/14/34	O.K.		
47	FE	70	LOIH	B	3/10/31	P.U.	9/ 4/31	O.K.	Olive size	
48	ML	44	ROIH recurrent	Gallie	4/ 7/31	Drained at operation. Healed in one month	4/ 1/32	O.K.	Normal	
49	LC	59	ROIH	Ox fascia	4/14/31	P.U.	7/10/31	O.K.		
50	WS	67	ROIH	B	4/21/31	P.U.	5/11/31	O.K.		Died—heart disease two years
51	JD	54	ROIH	Gallie	5/12/31	P.U.	5/21/33	O.K.		
52	AF	63	RDIH	Ox fascia	5/12/31	P.U.	11/30/31	Recurrence	Large and hard	
53	CD	49	ROIH scrotal	B	5/26/31	P.U.	12/ 4/31	O.K.	Normal	Testicle swollen three months
54	LS	45	LOIH sliding	Hotchkiss	5/26/31	P.U.	10/23/31	Recurrence		10/19/34 same
55	TR	48	LDIH recurrent	Gallie	6/26/31	P.U.	10/31/34	Recurrence		Still draining
56	AD	63	LDIH	Gallie	7/24/31	P.U.	10/ 2/31			
57	AG	52	ROIH	B	8/ 4/31	Infected, drained 16th day	9/ 2/31	O.K.		
58	MR	74	LOIH scrotal irreducible	B	8/15/31	P.U.	9/ 2/31	O.K.		
59	MR	74	ROIH scrotal irreducible	B	9/ 2/31	P.U.	1/21/33	O.K.	Normal	Died fractured skull 16 months later
59	JS	68	ROIH scrotal irreducible	B	9/ 2/31	P.U.	1/21/33	O.K.	Normal	
60	CG	62	ROIH strangulated	B	9/ 2/31	Mild infection	1/12/35	O.K.	Atrophied	
61	EC	70	LOIH scrotal irreducible	Ox fascia	9/ 8/31	Suppuration—three weeks	12/ 8/31	Recurrence	Normal	
62	AS	65	ROIH scrotal	B	9/ 8/31	P.U.	2/24/32	O.K.		
63	AS	65	ROIH scrotal	B	10/29/31	P.U.	12/ 2/31	O.K.		
64	AF	61	LOIH	Gallie	11/16/31	Suppuration—three weeks	2/ 2/35	O.K.	Normal	
65	TS	62	RDIH	B	1/ 5/32	P.U.	10/20/34	O.K.		
66	KK	31	ROIH recurrent	Gallie	2/16/32	P.U.	2/17/35	O.K.	Normal	
67	MN	28	RDIH recurrent	Gallie	3/ 7/32	P.U.	5/27/32	O.K.		
					3/22/32	P.U.				

ANALYSIS OF CASES OF DIVISION OF THE CORD IN THE REPAIR OF INGUINAL HERNIA—Continued

No.	Age	Diagnosis	Operation	Date	Wound Healing	Followed	Hernia Wound	Testicle	Remarks
68	BS 43	RDIH	Gallie	4/ 8/32	P.U.	10/14/34	O.K.		
69	BS	LDIH	Gallie	4/ 8/32	P.U.	10/14/34	O.K.		
70	JM 54	ROIH	B	4/12/32	P.U.	5/15/32	O.K.	Swollen	
71	MO 57	LDIH	Gallie	5/ 3/32	P.U.	7/ 1/32	O.K.	Slight atrophy	
72	MO	RDIH	Gallie	5/ 3/32	P.U.	7/ 1/32	O.K.	Slight atrophy	
73	AU 58	LOIH	B	5/24/32	P.U.	6/15/32	O.K.	Three-fourths normal	
74	IZ 65	RDIH	B	7/12/32	P.U.	2/17/35	O.K.	Normal	
75	IZ	LOIH	B	7/25/32	P.U.	8/15/32	O.K.	Normal	
76	WL 64	ROIH scrotal	B	7/29/32	P.U.	2/23/35	O.K.	Normal	
77	AC 64	RDIH	B	7/29/32	P.U.				
78	HN 59	ROIH	B	7/29/32	P.U.				
79	GF 57	LOIH sliding	Hotchkiss	8/ 8/32	P.U.				
80	DG 63	ROIH irreducible	B	9/20/32	P.U.	3/10/35	O.K.	Normal	
81	HL 73	ROIH recurrent	B	9/20/32	P.U.	10/11/32	O.K.		Cord swollen
82	HL	LOIH	B	9/20/32	P.U.	10/11/32	O.K.		
83	JM 55	ROIH scrotal	B	9/27/32	Drained at operation				
84	HD 34	LOIH irreducible	Gallie	11/15/32	P.U.	2/13/35	O.K.	One-half normal	Testicle swollen six weeks
85	HS 39	LOIH recurrent	Gallie	11/22/32	P.U.	11/ 4/34	O.K.	Atrophic	
86	MS 57	LDIH	Gallie	1/10/33	P.U.	1/30/33	O.K.		
87	HM 45	ROIH	B	1/26/33	P.U.	2/17/33	O.K.	Normal	
88	WB 33	LOIH recurrent	Gallie	2/23/33	P.U.	11/ 4/34	O.K.		
89	SM 46	LOIH recurrent	Gallie	3/ 7/33	Infected hematoma, drained eighth day				
90	ER 45	LOIH	B	3/22/33	P.U.				
91	MF 57	ROIH sliding	Gallie	4/ 4/33	P.U.	11/ 4/34	O.K.	Normal	
92	GS 57	ROIH	B	4/ 4/33	P.U.	5/ 8/33	O.K.		
93	HA 60	ROIH	B	4/11/33	P.U.	1/10/34	O.K.	Normal	
94	WW 48	LOIH scrotal	B	4/18/33	Deep infection	4/22/33			
95	IK 56	LOIH scrotal	B	4/18/33	P.U.	5/20/33			
96	EB 55	ROIH scrotal	B	4/18/33	P.U.	10/30/33	O.K.	Normal	Died fifth day, peritonitis
97	WW 47	LDIH recurrent	Gallie	5/ 2/33	P.U.	5/24/33	O.K.		Late scrotal abscess drained
98	WW 58	ROIH	B	5/16/33	P.U.				
99	LN 60	LOIH	B	6/ 6/33	P.U.	7/14/33	O.K.		
100	JW 57	RDIH recurrent	Gallie	6/ 6/33	P.U.				
101	LC 49	LOIH recurrent	Gallie	6/ 6/33	P.U.	8/11/33	Recurrence	Normal	
102	JS 47	LOIH recurrent	Gallie	6/ 6/33	P.U.	6/28/33	O.K.		
103	LR 43	RDIH recurrent	Gallie	6/13/33	P.U.	8/16/33	Recurrence		

100	FS	56	RDIH recurrent	Gallie	7/11/33	P.U.	9/12/34	Recurrence	Normal	8/7/33 orchidectomy
101	FS	46	LDIH recurrent	Gallie	7/11/33	P.U.	9/12/34	Recurrence	Normal	
102	SG	50	ROIH recurrent	Gallie	7/18/33	P.U.	8/ 9/33	O.K.		
103	DH	52	RDIH	Gallie	7/25/33	Extensive suppuration	11/ 4/34	O.K.	Removed	
104	MR	64	ROIH	Gallie	8/15/33	P.U.	11/ 7/34	O.K.	One-fourth normal	
105	WB	73	RDIH	B	8/22/33	P.U.	3/11/35	O.K.	Normal	Testicle swollen one month
106	WB	73	RDIH	B	9/12/33	P.U.	10/20/33	O.K.	Swollen	
107	JR	66	ROIH recurrent	B	9/12/33	P.U.	10/20/33	O.K.	Swollen	
108	AS	62	LDIH	B	10/24/33	P.U.	11/14/34	O.K.		
109	EK	64	ROIH scrotal	B	10/25/33	P.U.	12/12/33	O.K.	Normal	
109	GS	53	RDIH recurrent	Gallie	11/14/33	P.U.	1/31/34	O.K.	Enlarged	Hydrocele—9/19/34 orchidectomy
110	AR	70	ROIH irreducible sliding	Hotchkiss	12/ 5/33	P.U.	11/ 4/34	O.K.		
111	BS	52	LDIH	Hotchkiss	12/ 5/33	P.U.				
112	WQ	58	LOIH sliding	Ox fascia	2/ 7/34	P.U.	8/ 6/34	O.K.		
113	LC	62	ROIH	Hotchkiss	2/17/34	P.U.	12/26/34	O.K.	Normal	
114	PM	42	RDIH	B	2/27/34	P.U.			Normal	Scrotum swollen for one month Testicle swollen one month
115	KH	49	RDIH recurrent	Gallie	3/12/34	P.U.	8/28/34	O.K.	Normal	
116	LC	60	LOIH	B	3/13/34	P.U.	2/18/35	O.K.	Removed	
117	FP	48	LOIH	B	4/ 5/34	P.U.	5/ 2/34	O.K.	Swollen	
118	VW	53	RDIH recurrent	Gallie	4/10/34	P.U.	6/15/34	O.K.		
119	JL	57	ROIH	Gallie	4/17/34	P.U.	6/27/34	O.K.		Draining, two sutures sloughed Testicle swollen two months Testicle swollen two months
120	FP	77	LDIH	B	4/26/34	P.U.				
121	AD	51	ROIH scrotal	Gallie	5/22/34	P.U.	6/29/34	O.K.	One-half normal	
122	RM	59	ROIH	B	6/12/34	P.U.	3/ 4/35	O.K.		
123	EM	48	ROIH recurrent	Gallie	6/12/34	P.U.	8/10/34	O.K.	Normal	
124	TG	59	ROIH	B	6/20/34	P.U.	8/15/34	O.K.	Normal	Testicle swollen one month
125	FW	67	LOIH	B	6/20/34	P.U.	8/15/34	O.K.		
126	WT	52	RD and OIH	B	6/19/34	Infection 13th day	8/ 6/34			
127	HS	70	LDIH scrotal	Gallie	7/10/34	P.U.	9/14/34	O.K.		
128	CM	55	ROIH	B	7/31/34	P.U.	11/ 1/34	O.K.		
129	VC	48	LOIH	Gallie	7/31/34	P.U.	11/ 1/34	O.K.		Testicle swollen one month
130	HM	58	RD and OIH	Gallie	8/28/34	P.U.	11/ 2/34	O.K.		
131	WS	65	ROIH	Gallie	8/28/34	P.U.	11/ 2/34	O.K.		
132	RG	33	ROIH recurrent strangulated	Gallie	9/18/34	P.U.	11/ 2/34	O.K.		
133	MR	38	LOIH recurrent	B	10/ 2/34	P.U.	11/ 2/34	O.K.	Swollen	
134	PJ	29	LOIH recurrent	B	10/ 2/34	P.U.	12/ 7/34	O.K.		Testicle swollen two months
135	JP	53	ROIH recurrent	Gallie	10/ 2/34	P.U.	11/12/34	O.K.		
					3/23/33	O.K.				
					12/ 9/31	Recurrence				Testicle swollen two months
					12/16/31	Recurrence			Atrophied	

ANALYSIS OF CASES OF DIVISION OF THE CORD IN THE REPAIR OF INGUINAL HERNIA—*Concluded*

No.	Age	Diagnosis	Operation	Date	Wound Healing	Followed	Hernia Wound	Testicle	Remarks
136 GH	47	LOIH recurrent X 3	Gallie	6/24/31	P.U.	11/27/34	O.K.		
137 LB	53	LOIH	W. Andrews	8/12/31	P.U.	9/ 8/31	O.K.		
138 MS	56	ROIH	B	8/12/31	P.U.	12/22/31	O.K.		
139 OK	53	RDIH	B	12/23/31	P.U.	1/12/32	O.K.		
140 PS	54	RD and OIH	W. Andrews	1/30/32	P.U.	2/18/35	O.K.	Two-thirds normal	Testicle swollen one month
141 TP	46	RDIH recurrent	B	5/18/32	P.U.	5/ 6/34	O.K.	Atrophied	
142 JM	61	LOIH scrotal irreducible	Gallie	4/12/33	Infection 17th day	12/18/34	O.K.	Removed	5/3/33 orchidectomy
143 WW	60	LDIH recurrent incarcerated	B	6/15/33	P.U.	6/ 3/34	Recurrence		11/10/34 same
144 WT	59	ROIH irreducible	B	3/ 9/34	P.U.	6/ 3/34	O.K.	Atrophied	
145 DS	69	LOIH sliding	Hutchkiss	3/16/34	P.U.	1/31/35	O.K.	Normal	
146 FR	47	RDIH recurrent	B	10/25/34	P.U.	3/ 5/35	O.K.		
147 FH	56	LDIH recurrent	Gallie	10/18/28	Mild infection, tenth day	1/ 6/29	O.K.		
148 FS	56	LOIH recurrent	Gallie	12/ 3/30	P.U.	10/26/33	O.K.	Normal	
149 FL	57	LDIH recurrent	Gallie	11/ 7/31	Infected third day	6/24/32	O.K.		Drained eight weeks
150 PS	66	RDIH	Gallie	5/ 9/31	Infected sixth day	8/28/31	O.K.		
		LDIH	Gallie	5/ 9/31	Infected sixth day	8/28/31	O.K.		Drained four weeks
151 JD	55	LOIH recurrent	Gallie	5/16/31	Infected third day	12/27/34	O.K.	Normal	Drained five weeks
152 AK	51	RDIH recurrent	B	8/ 4/31	P.U.				
153 SS	44	ROIH scrotal	Gallie	9/19/31	P.U.	11/27/31	O.K.	Swollen	
154 JH	74	ROIH strangulated	B	9/30/31	P.U.	10/20/31	O.K.		
155 WF	54	LOIH scrotal	Gallie	8/ 5/32	P.U.				
156 JM	53	LOIH scrotal	B	7/20/32	P.U.	12/27/34	O.K.	One-half normal	Died 20th day, pneumonia
157 JM	69	ROIH sliding incarcerated	B	9/25/32	Drained at operation. Healed in 15 days				
158 SD	61	RDIH	Gallie	12/ 8/32	Drained at operation. Healed in 15 days	5/25/33	O.K.	Normal	

159	MP	56	RDIH recurrent	Gallie	12/ 2/32	12/ 6/32	Died fourth day, pneumonia
160	AS	42	LDIH sliding	Gallie	1/31/33 P.U.	3/29/34 O.K.	Atrophied
161	JL	59	RDIH recurrent	Gallie	3/11/33 Drained at operation. Healed in ten days	12/27/34 O.K.	One-fourth normal
162	JR	50	RDIH recurrent	Gallie	3/10/33 P.U.	12/27/34 O.K.	Normal
	JR		LOIH	B	3/10/33 P.U.	12/27/34 O.K.	Normal
163	TT	47	RDIH recurrent	Gallie	4/21/33 Infected tenth day		
164	AW	53	ROIH scrotal	B	5/12/33 P.U.	8/31/33 Recurrence	
165	HH	69	LOIH	B	6/13/33 P.U.	8/31/33 O.K.	
	HH		ROIH	B	6/13/33 P.U.	6/28/34 O.K.	Normal
166	HH	35	ROIH	B	7/ 5/33 Mild infection		
167	AB	42	ROIH scrotal	B	7/ 7/33 P.U.		
168	JP	72	RDIH	B	9/26/33 P.U.	12/27/34 O.K.	One-half normal
169	CE	70	ROIH scrotal incarcerated	B	7/ 8/33 Infected 35th day	12/27/34 O.K.	Removed
170	PS	51	RDIH recurrent X 2	B	3/31/34 Hematoma third day. Healed 28th day	12/27/34 Recurrence	One-half normal
171	CF	63	LDIH	Gallie	6/15/34 P.U.		8/12/33 orchidectomy. Healed 12th week
172	AP	66	RD and OIH	B	7/ 3/34 P.U.	9/27/34 O.K.	3/19/35 same
173	JB	41	ROIH	B	6/29/34 Infected seventh day	12/27/34 O.K.	7/17/34 orchidectomy. Healed seven days
174	WM	38	ROIH sliding	B	7/27/34 P.U.		
175	JW	45	RD and OIH	B	10/ 5/34 P.U.		
176	GM	40	ROIH	B	6/ 9/31 P.U.		
177	WM	46	RDIH	Gallie	4/ 2/32 P.U.		
178	GB	63	LOIH	B	10/22/32 Infected, healed in two months		
179	JR	44	LDIH recurrent	Gallie	12/15/33 P.U.	12/27/34 Recurrence	Swollen
180	RE	70	LDIH	Gallie	3/22/34 P.U.		
181	FM	60	ROIH	B	8/23/34 P.U.		
182	MA	64	RDIH	Gallie	12/15/34 P.U.	12/31/34 O.K.	Swollen
183	LB	45	LOIH recurrent	McArthur	12/21/34 Infected one month	2/ 8/35 O.K.	Normal
							Testicle swollen for one month

The scrotum is elevated on a bridge for ten days. There is always considerable swelling accompanied by redness of the skin and edema of the scrotum. We must admit that in some patients, gangrene seemed imminent and actually did occur in four. The patients are kept in bed for the usual time depending on the type of hernia, and are advised to wear a suspensory until the swelling has entirely subsided, a period of from four to eight weeks.

Many of the testicles atrophy, in fact, some almost completely disappear; but it is surprising how many do not, and we frequently have to refer to our records in following our postoperative results in order to ascertain in which patients the cord has been divided.

Analysis of 200 Cases.—Complete division of the spermatic cord has been employed in the repair of 200 inguinal herniae at the Hospital for Ruptured and Crippled and Bellevue Hospital (Fourth Division). The cord was divided on one side in 166 cases, and 17 patients had hernia repair with cord division on both sides.

The youngest patient was 28 years of age and the oldest 80. The average age for the series was 54.6 years. The number of patients for each decade is shown in Table I.

TABLE I

Age

Oldest	80 years
Youngest	28 years
Average	54.6 years

<i>Decades</i>	<i>Cases</i>
20—29	2
30—39	12
40—49	40
50—59	67
60—69	46
70—79	15
80—	1

CASE 67.—M. M., aged 28 years, was operated upon in June, 1929, for an R.O.I.H. which recurred five months later. A Gallie fascia repair of the recurrent hernia was done on March 11, 1930, and the hernia recurred one year later. At the third operation, March 22, 1932, the sac was intimately adherent to the cord and contained adherent omentum; all landmarks were very much obliterated. The cord was divided and a Gallie fascia repair effected. Unfortunately no follow up has been secured.

The procedure was employed in all types of inguinal hernia as shown in Table II, but was particularly favored in direct or indirect recurrent types to effect a stronger repair, and in older men where it was felt that the operating time could be shortened.

Nine cases in the series are dead, six (3.2 per cent) being postoperative deaths. One case (32) died of pneumonia three and a half years after operation, one (58) died of a fractured skull following an accident 16 months after

TABLE II
Type of Hernia

	<i>Simple</i>	<i>Scrotal</i>	<i>Sliding</i>	<i>Irreducible</i>	<i>Recurrent</i>
Oblique	47 (3)*	24	12 (1)	17 (1)	25 (4)
Direct	31 (1)	3	1	1	34 (10)
Direct and oblique ...	5	—	—	—	—
<hr/>					
Total ... 200 (20)*	83 (4)	27	13 (1)	18 (1)	59 (14)
Recurrence rate....	4.8%	0	7.7%	5.5%	23.7%

* Figures in parenthesis denote number of recurrences.

operation, and one (51) died of heart disease two years after operation. The six postoperative deaths were as follows:

CASE 3.—J. W., aged 65 years, presented a recurrent R.D. and O.I.H. with sliding cecum and the appendix in the sac. Under spinal anesthesia the appendix was removed and a Gallie fascia repair done after dividing the cord. Patient developed pneumonia and died on the third postoperative day.

CASE 26.—E. W., aged 73 years, under spinal anesthesia a ventral hernia was repaired and a Gallie fascia repair, after dividing the cord, was done for a recurrent R.D.I.H. The operating time was 40 minutes. Patient developed pneumonia and died on the third postoperative day.

CASE 44.—H. S., aged 60 years. On December 18, 1930, a Bassini type repair was done for a large R.O.I.H. irreducible, with a scrotal sac containing adherent small intestine. At operation a small hole was torn in the intestine in freeing it from the sac, the rent sutured, and the bowel reduced. Patient died on the 11th postoperative day. Autopsy disclosed a plastic peritonitis and an abscess of the abdominal wall.

CASE 90.—W. W., aged 48 years. Bassini type of repair was done on April 18, 1933, for an L.O.I.H. with a large scrotal sac. Patient died of peritonitis on the fifth postoperative day. Autopsy revealed that a portion of omentum had been tied off in the neck of the sac with the purse string suture and there was deep infection of the wound and a spread of the infection retroperitoneally.

CASE 154.—J. H., aged 74 years, presented a strangulated R.O.I.H. which was reduced after dividing the cord. A Bassini type repair was done. The wound healed by primary union but the patient developed pneumonia and died on the 20th postoperative day.

CASE 159.—M. P., aged 56 years. Gallie fascia repair of a recurrent R.D.I.H. was done on December 2, 1932. Patient developed pneumonia and died on the fourth postoperative day.

A study of the effects of the procedure on wound healing reveals that 159 wounds healed by primary union, six were drained at the lower angle at the time of operation and healed in from 10 to 30 days, while 33 wounds (17.5 per cent) became infected. In most instances the infection was of no serious consequence and responded to adequate drainage. However, one case, in which the intestine was opened at operation, developed a deep wound infection and died of peritonitis; and another case in which omentum had been ligated in the neck of the sac, developed a deep wound abscess and died of peritonitis. However, in four cases late infection set in from the sixth to the 35th day due to a necrosis of the testicle, necessitating orchidectomy. It may

he noted that none of these four cases showed a recurrence of the hernia when last examined.

CASE 102.—S. G., aged 50 years, had a Gallie fascia repair of a recurrent R.O.I.H. The wound was opened widely on the sixth day because of extensive suppuration. The infection spread, involving the distal segment of the cord and testicle so that an orchidectomy was done on the 13th day. Recovery was prompt, and 15 months later the hernia repair was found to be solid.

CASE 142.—J. M., aged 61 years, presented a large irreducible serotal L.O.I.H. for which a Gallie fascia repair was done after dividing the cord to facilitate a repair. The scrotum became quite swollen and was drained on the 17th postoperative day. It was soon apparent that the testicle was necrotic, and four days later orchidectomy was done followed by prompt healing of the wound. There was no recurrence of the hernia when the patient was examined 20 months later.

CASE 169.—C. E., aged 70 years. This patient, who was very obese, was admitted with a large serotal hernia on the right side which had recently become incarcerated, and a large serotal hernia on the left which had been irreducible for several years. Operation was done under spinal anesthesia and the right cord divided to facilitate repair. No attempt was made to repair the left side. The scrotum was moderately swollen after the operation but not until the fifth week was fluctuation elicited and the scrotum drained and the testicle removed. Wound healing was slow but was complete 12 weeks after the original operation. Patient was examined 17 months later and there was no evidence of recurrence. The unoperated left hernia gave him no trouble.

CASE 173.—J. B., aged 41 years. Bassini type repair of an R.O.I.H. On the seventh day there was evidence of wound infection, which spread into the scrotum and involved the testicle; orchidectomy was done 18 days after operation, followed by prompt wound healing in one week. Six months later, patient was examined and the wounds were healed; there was no evidence of a recurrence of the hernia.

One other case remained free of infection but developed a large hydrocele. It was considered advisable, in view of the already damaged blood supply and the fact that a typical hydrocele operation would interfere with the collateral circulation, to remove the testicle with the hydrocele sac five months after the hernia repair.

CASE 116.—L. C., aged 60 years. Patient had a L.O.I.H. and a Bassini type repair was done with division of the cord on the left side only. The wounds healed by primary union but the patient developed a large hydrocele because the serotal part of the sac had not been removed. This was removed at operation five months later, and the testicle, although normal in size and appearance, was removed because of its close relation to the hydrocele.

Although 169 cases returned to the clinic and the condition of the hernia wound was noted, only 79 follow up notes report the condition of the testicle. A fairly common observation was moderate swelling of the testicle for one or two months after operation followed by diminution in the swelling to normal or going on to atrophy. One testicle remained swollen for six months and another for one year. We believe it fair to assume that if marked atrophy had occurred in those patients in which the condition of the testicle was not noted, the majority of them would have noticed it themselves and called our attention to the fact. The testicle was recorded normal in size in 42 instances (25 of which were followed from one to five years). Incidentally, all cases

subjected to bilateral division of the cord were found—where mention was made of the condition of the testicle—to have normal size testicles on both sides. Eleven cases showed slight atrophy, and 11 others showed atrophy to one-half or less of the normal size.

An analysis of the follow up records reveals that 31 cases were not traced after they left the hospital. Of the 169 that returned for one or more examinations, 20 (11.8 per cent of the followed cases) were found to have a recurrence of their hernia. One case recurred as early as one month after operation, and one as late as 39 months, with an average interval of 9.5 months from operation to recurrence. As might be expected, the highest recurrence rate (14 recurrences out of 59 operations occurred in those cases that were operated on for a once, or twice recurrent hernia. The number of recurrences for the different types of hernia is shown in Table II; and Table III shows the rate of recurrence for the different types of operation.

TABLE III
Percentage of Recurrences

Type of Operation	No. of Cases	No. of Recurrences
Bassini	80	4 or 5.0%
Gallie	87	10 or 11.5%
Ox fascia	25	5 or 20.0%
Hotchkiss	5	1 or 20.0%
Wyllys Andrews.....	2	—
McArthur.....	1	—
	200	20 or 10.0%

Analyzing the death rate: There were four deaths (the patients were between 60 and 80 years) in 62 operations, a mortality of 6.5 per cent. Three of the deaths were from pneumonia. This was before we were using CO₂ and oxygen as a routine after all spinal anesthetics. It is quite possible that its use might have prevented some of them. The deaths from peritonitis were distinct technical errors on our part.

These patients have been operated on by a fairly large group of surgeons in each hospital, and we are all impressed with: first, the value of cord division in diminishing the operating time in elderly people; and second, the efficiency in insuring a more perfect repair in sliding hernia and in many types of recurrent hernia.

COMMENT.—One hundred and nineteen of the 182 cases occurred in the fifth, sixth, seventh and eighth decades, the fifth predominating. Nearly all the younger patients had cord division for recurrences. The recurrence rate for the latter group is high, 23.7 per cent, but we believe we have obtained better results than we would have without division of the cord. In the non-recurrent cases our percentage of failures is distinctly lower than we would have had without division of the cord. This applies especially to the sliding types with a recurrence rate of 7.7 per cent.

TABLE IV
Percentage of Infections

Type of Operation	No. of Cases	No. of Infections
Bassini	80	11 or 13.7%
Gallie	87	11 or 12.6%
Ox fascia	25	10 or 40.0%
Hotchkiss	5	—
Wyllis Andrews	2	—
McArthur	1	1 or 100%
	200	33 or 17.0%

The infection rate is lamentably high (Table IV). An infected vas deferens might explain some of these; and in a certain number of cases we have cauterized the stumps but not in a sufficient number to ascertain whether this had any definite bearing. Forty per cent of the cases in which ox fascia was used became infected, and this suture material has been discarded. Eliminating this group and also the four cases in which the testicles sloughed, plus the two with sloughing of the lower end of the hernial sac, leaves 17 infections in 169 operations, a percentage of 10 per cent. This corresponds very closely to the results obtained in the Gallie repair without division of the cord. Two patients later developed infections, one in the inguinal wound, and the other, a sinus in the scrotum. We assumed the testicle was sloughing in each instance but on incising the scrotum a slough of the lower end of the hernial sac was found. The wounds healed promptly after its removal and the testicles were not involved.

THE UNDESCENDED TESTIS

ITS FATE AFTER SATISFACTORY SCROTAL ANCHORAGE

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JOHN HUNTER¹¹ believed that the undescended testis failed to reach the scrotum because of inherent imperfection. With the advent of aseptic surgery, operative procedures have been developed which will permit of satisfactory scrotal anchorage of the incompletely descended testis in the majority of instances. Though the deformity may be corrected by surgery and a good cosmetic result obtained, considerable doubt still persists in the minds of most medical men concerning the functional worth of scrotal transference of the undescended testis.

That the imperfectly descended testis is aspermatic has long been known. The cause for its inability to develop complete spermatogenesis has been the subject of considerable speculation and experimentation. Piana¹⁸ and Crew^{5a} have each suggested that the higher body temperature is unfavorable for the elaboration of mature germinal epithelium in a retained testis. The researches of Moore¹⁷ and Fukui⁸ gave complete support to this hypothesis. Moore's suggestion that the scrotum is a temperature regulating mechanism appears to be well established for the normal testis, for after elevation of the completely descended testis to the abdomen, upon its return to the scrotum, there is restoration of normal spermatogenesis (Fig. 1).

Many, including the writer,²³ have inferred that the undescended testis would develop normally when afforded the advantages which the scrotum accords the testis which descends in the normal manner. No proof, however, has yet been adduced to indicate whether this surmise is correct or not. That rationalization may frequently lead to error is a matter of general knowledge, even though not sufficiently appreciated. Speculation as to the verity of a conclusion reached by a process of rationalization can be done away with only when the subject under discussion has been subjected to the acid test of direct experiment.

Histology of the Retained Testis.—The writer²³ has elsewhere summarized at some length certain facts concerning the gross and microscopic anatomy of the testes which relate to the aspermatic condition of the undescended testis. Briefly it may be said that the normal testis grows but slightly from birth to puberty, and similarly, during this interval of time there are very few histologic changes. The undescended testis before puberty resembles its fellow in the scrotum in both matters of weight and minute anatomy. With the onset of puberty, however, the normal testis shows a sharp increase in weight accounted for by the elaboration of a mature germinal epithelium and the ap-

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pearance of spermatozoa. The undescended testis similarly exhibits these changes but in lesser degree. In the retained testes of children just past



FIG. 1.—(A) Section from the normal testis of an adult dog. (B) The same testis after having been in the abdomen 37 days. (C) The other scrotal testis of the same dog 190 days after scrotal replacement; it was also in the abdomen for 37 days. No change attends the elevation of the prepuberty dog's testis to the abdomen.

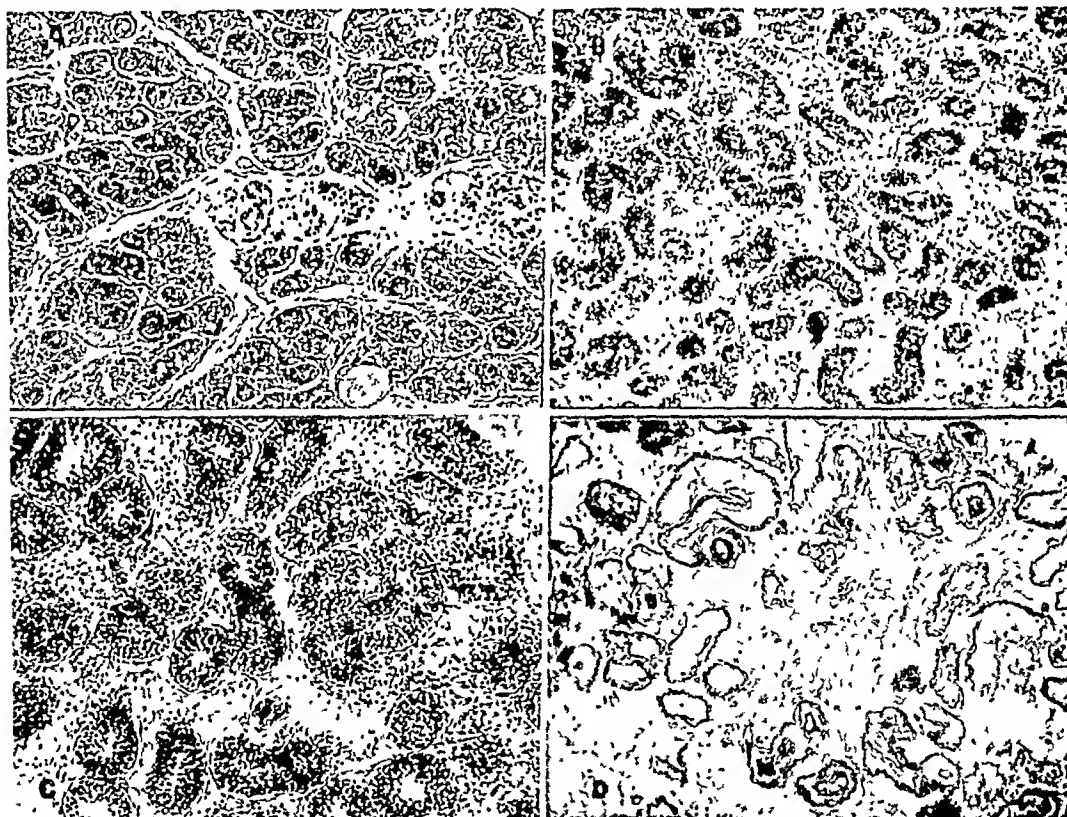


FIG. 2.—(A) Section from abdominal testis of a seven months old premature. (B) Scrotal testis of an 11 year old child. (C) Undescended testis of a 13 year old boy. Spermatozoa are not apparent in the section, but a fairly mature germinal epithelium is present. (D) Undescended testis of a 56 year old man.

puberty spermatogonia may be demonstrated in the seminiferous tubules in abundance, but spermatozoa in my experience have not been observed. With increasing years the germinal epithelium becomes more and more atrophic,

such that in retained testes removed past the meridian of life, only the outlines of the seminiferous tubules occasionally persist (Fig. 2 D).

The occurrence of spermatozoa in retained testes in the young has been described, but their presence is decidedly unusual. An active spermatogenesis is probably never maintained. It would appear that inasmuch as the operation of orchiopexy has been practised for more than 50 years, information should be readily accessible as to what scrotal transference profits the incompletely descended testis. Even when acknowledgment is made of the admitted difficulties surrounding the problem of obtaining satisfactory examinations during life, it is astonishing how little information is available with reference to this important question. A few isolated instances where spermatozoa have been observed in the semen of patients after bilateral orchiopexy have been reported. No mention of this significant item has come to the writer's attention in the literature of the last fifteen years.* Reports after orchiopexy have been concerned largely with the size, position, and general cosmetic result of the operation.

Purpose and Method.—The purpose of this paper is to set forth the results of scrotal transference of the undescended testis as it relates to the question of spermatogenesis. Nine years ago the writer first employed and later described a method of obtaining satisfactory scrotal anchorage of the undescended testis (Fig. 10). Three years ago it was appreciated that this method of orchiopexy permitted determination of the influence of the scrotal position upon the histology of the undescended testis. A small piece of testicular tissue was removed for histologic examination at the time of the initial operation, and again later when the cutaneous union between the thigh and scrotum was undone. Similar observations have also been made upon a bull, several pigs, and dogs with incomplete testicular descent. Semen examinations have been possible in some of the cases of human cryptorchidism after bilateral orchiopexy.

Results.—In 1931 through the courtesy of Drs. C. P. Fitch and W. L. Boyd, Professors of Veterinary Medicine at the University of Minnesota, it was my privilege to operate upon a young Holstein bull six months old, of valuable pedigree, for bilateral cryptorchidism. My colleague, Dr. M. H. Manson, assisted with the operation.

Satisfactory anesthesia was obtained by the intraspinal injection of 150 mg. of novocaine. The bull's hind quarters in a few minutes failed to support him and he was fastened in the dorsal decubitus position. After preparation of the abdomen by clipping the hair with shears, iodine was applied and an aseptic laparotomy was performed. Both testes were found within the peritoneal cavity. There was considerable torsion of the left spermatic cord without infarction of the testis. The testis could not be adequately mobilized to bring it outside the abdomen and consequently it was excised. The right

* A very interesting discussion of the subject has just appeared under the title of "Clinical Study of the Spermatogenesis of Undescended Testes," by D. W. MacCollum of Boston, in the Arch. of Surgery, vol. 31, p. 290, August, 1935.

testis, on the contrary, was brought into the scrotal pocket with relative ease after division of some of the avascular bands of connective tissue surrounding the spermatic vessels. A heavy, double, silk suture secured to the tunica albuginea was brought through the skin of the scrotum and tied over a small gauze dressing to maintain the testis in as favorable a position as possible.

The bull made an uneventful convalescence and the immediate result was all that could be desired. With the elapse of time, however, the testis retracted to the upper portion of the scrotum, a behavior well known in human cases after the Schüller-Bevan^{19, 2} type of orchiopexy (Fig. 3).

On January 29, 1932, Professor Boyd wrote me the following comprehensive note concerning the subsequent status of the bull. "I wish to report that the young Holstein sire on which you performed orchiopexy during



FIG. 3.—(A and B) Photographs of bull, made about nine months after right orchiopexy. The testis is small and has retracted into a high scrotal position.

February, 1931, made a complete recovery without any suppuration. After he had fully recovered he was shipped home. During the month of June he was permitted to serve three virgin heifers, two of which failed to again come in estrum. The third appeared in estrum at the regular period and was served by another sire. The two in which there was a cessation of estrum were thought to be in calf and were cared for as such. The bull developed into an average sized animal for his age and though he developed a good crest and other male characteristics, his conformation proved a disappointment to the owner and he was not again placed in service. During the early part of December, 1931, I conducted a careful physical examination of this bull and found his testis, which was situated in the upper region of the scrotum, to be very small, more or less flattened, and adherent to its covering. I massaged his seminal glands and the discharge collected at the opening of the sheath failed to show the presence of spermatozoa. I then examined the heifers supposedly in calf and found them open or not pregnant. The cessation of

estrum in each instance was the result of a retained corpus luteum. We then permitted the bull to serve a cow which he did in a very rapid and vigorous manner. The discharge from this service which was largely water-like was carefully examined for the presence of spermatozoa and found negative. The superintendent then decided it was wise to castrate this animal to which I consented.

"I spoke of securing the testis for histologic studies but apparently failed to impress them with this request. I wrote to the veterinarian upon arriving home, and during our meeting in early January I was informed that the animal had been castrated and that the testis was probably lost. I believe that we can safely consider that the animal in question developed in a very masculine way just as any normal sire would do, but I do not believe that spermatogenesis ever took place."

In 1932 I brought the testes of a dog, with bilateral failure of testicular descent, into the scrotum, and my associate, Dr. Charles Rea, has recently done a similar procedure on three dogs with unilateral failure of descent. Subsequent biopsies of the testes failed to show a mature germinal epithelium but as yet smears from the cut surface of the testis and from the seminal vesicles have not been made nor has the semen been examined for spermatozoa. One of the likely hindrances to a satisfactory result is the difficulty of getting the testis well down in the scrotum and keeping it there.

With the future cooperation of Professor Fitch it was possible to secure several young pigs with unilateral or bilateral failure of testicular descent through the courtesy of several veterinary surgeons in the environs of Minneapolis. A few additional pigs were also obtained at the stockyards in South St. Paul with the coöperation of Mr. Ralph Lewis.

In all, 15 pigs were brought to the laboratory of experimental surgery for the purposes of this study. Several were found unsuitable because both testes had been previously removed, or the supposedly retained testis was absent. Three of the group presented inguinal retention of the testis and in each instance the testis was readily brought into the scrotum. The results of these experiments are summarized in Table I. The writer here gratefully acknowledges the help of his associate, Dr. Louis Sperling, in the operative procedures, who at the time was occupied in the laboratory with experimental features of bowel obstruction.

COMMENT

It is apparent from these observations that scrotal transference has a favorable influence on the undescended testis. In the three pigs with inguinal retention of the testis, adult germinal epithelium developed in each instance after orchiopexy. In one, the final size of the transplanted testis (Fig. 4, Table I) together with the presence of a mature spermatogenesis in all the seminiferous tubules attested the restoration of the normal condition (Fig. 4). In the other two, in which the scrotal anchorage, as far as could be determined, was just as satisfactory, a normal adult spermatogenesis was apparent only here and there in the sections. Nevertheless, when these sections are contrasted with the histologic picture presented by retained testes of adult pigs or

TABLE I
RESULTS OF ORCHIOPEXY ON PIGS FOR UNDESCENDED TESTIS

No.	Age	Weight (lbs.)	Date of Operation	Position of Testis	Procedure	Histologic Findings at Time of Operation	Subsequent Findings and Final Status of Testis
1	Adult	200	2/6/32	Left descended; right previously removed	Excision of left testis	Left normal	Weight of removed testis and epididymis, 360 Gm.
2	Adolescent		2/13/32	Left scrotal; right inguinal	Biopsy both; orchiopexy of right	Both prepuberty	12/7/32 pig killed. Weight of left testis, 392 Gm.; weight of right, 135 Gm.; surrounded by dense connective tissue; scattered islands of normal spermatogenesis with spermatozoa
3	Adult	186	2/13/32	Both intraperitoneal	Both excised	Both atrophic and aspermatic	Weight of right, 120 Gm.; weight of left, 116 Gm.
4	4 wks.	14	2/22/32	Right scrotal; left inguinal	Bilateral biopsy and left orchiopexy	Both prepuberty	Killed 4/22/33. 6.5 × 12 × 6 cm. Both equal size; mature germinal epithelium with myriads of spermatozoa in each testis
5	Adolescent	50	2/22/32	Right scrotal with hernia; left inguinal testis with small hernia	Repair of right hernia; repair of left hernia and orchiopexy	Both prepuberty	Killed 6/30/32. Granulomatous tumor about right testis. Weight of left, 199 Gm.; mature germinal epithelium with scattered spermatozoa
6	Adolescent	90	3/5/32	Right scrotal; left absent			
7	Adult	180	3/5/32	Right scrotal; left abdominal	Both excised; left could not be brought into scrotum	Right normal; left atrophic	Weight of right testis, 400 Gm.; weight of left testis, 70 Gm.

THE UNDESCENDED TESTIS

8	Adult	220	3/5/32	Right apparently previously re-moved; left scrotal	Left excised	Left normal	Weight of left testis and epididymis, 450 Gm.
9	Adolescent	40	5/9/32	Both intraperitoneal	Biopsy both testes; right left in abdomen; left anchored beneath skin of groin	Left normal	
10	6 wks.	28	6/30/32	Right removed; left intraperitoneal	Anchorage of left testis beneath skin of groin	Both prepuberty	Six weeks after operation developed hernia and granulomatous mass about left transplanted testis. Killed 7/20/32
11	5 wks.	27	6/30/32	Right intraperitoneal; left previously removed	Anchorage beneath skin of groin	Prepuberty testis	Died bronchopneumonia 7/6/32. Weight of right testis 18.8 Gm.; weight of left testis 18.8 Gm.
12	3 mos.	62	6/30/32	Right removed; left intraperitoneal	Anchorage of left testis in groin	Prepuberty testis	Initial measurements of right testis— $1\frac{1}{4} \times 27/32 \times 15/16$ inches. Pig killed 11/26/32. Measurements— $2\frac{3}{8} \times 1\frac{5}{16} \times 1\frac{5}{16}$ inches. Atrophic histologically
13	3 mos.	62	7/2/32	Both testes previously removed	Exploratory	Prepuberty testis	Died of peritonitis 7/4/32
14	4 wks.	25	7/2/32	Right absent; left intraperitoneal	Biopsy and anchorage of left testis in groin	Prepuberty testis	Killed 4/22/33. Initial measurements— $1\frac{3}{8} \times 1 \times \frac{3}{2}$ inches. Final measurements— $1\frac{3}{4} \times 1\frac{3}{8} \times 1\frac{3}{8}$. Atrophic histologically.
15	5 wks.	20	7/19/32	Right scrotal; left intraperitoneal	Biopsy of both; anchorage of left in groin	Prepuberty testis	Killed 11/26/32. Measurements of right scrotal testis— $2\frac{3}{8} \times 1\frac{5}{16} \times 1\frac{5}{16}$ inches; histologically normal. Left testis involved in large granulomatous mass.

that of abdominally retained testes anchored beneath the skin of the groin, it is obvious that the germinal epithelium is improved by scrotal transference (Figs. 4 and 5).

Results after Orchiopexy in Man.—In the human cases, as has been stated, an opportunity was afforded to remove a small piece of tissue for biopsy at



FIG. 4.—(A) Inguinal testis of a four weeks old pig. The histology of the scrotal and the retained testis was quite the same (prepuberty testis). (B) Photograph several months later. Both testis exhibit considerable growth (Fig 2, Table I). (C) Section of retained testis 14 months after orchiopexy. A complete spermatogenesis is present.

the time that the cutaneous union between scrotum and thigh was undone, the testis meanwhile having been in the scrotum for several months. By and large, the results of these microscopic examinations were somewhat disappointing. Though the state of the germinal epithelium, on the whole, ex-

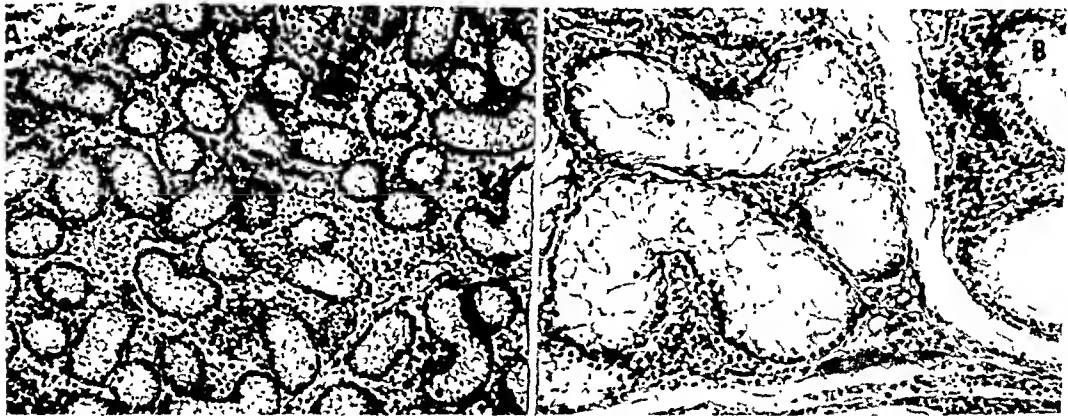


FIG. 5.—(A) Section of prepuberty abdominal testis of pig (Fig 11, Table I). (B) Same testis, five months after anchorage beneath the skin of the groin. There is no evidence of a mature germinal epithelium.

hibited distinct improvement over that observed initially, nevertheless the normal adult state was never attained. Yet, in the only instance in which the testis* has been available for examination at a date remote from the per-

* This boy (see Table II, Case 3) was killed in a motorcycle accident sixteen months after the last scrotal detachment. Through the cooperation of Dr. George R. Dunn of Minneapolis, and the kindly attitude of the father, permission was obtained to secure the testes for histologic examination. (See Fig. 6.)

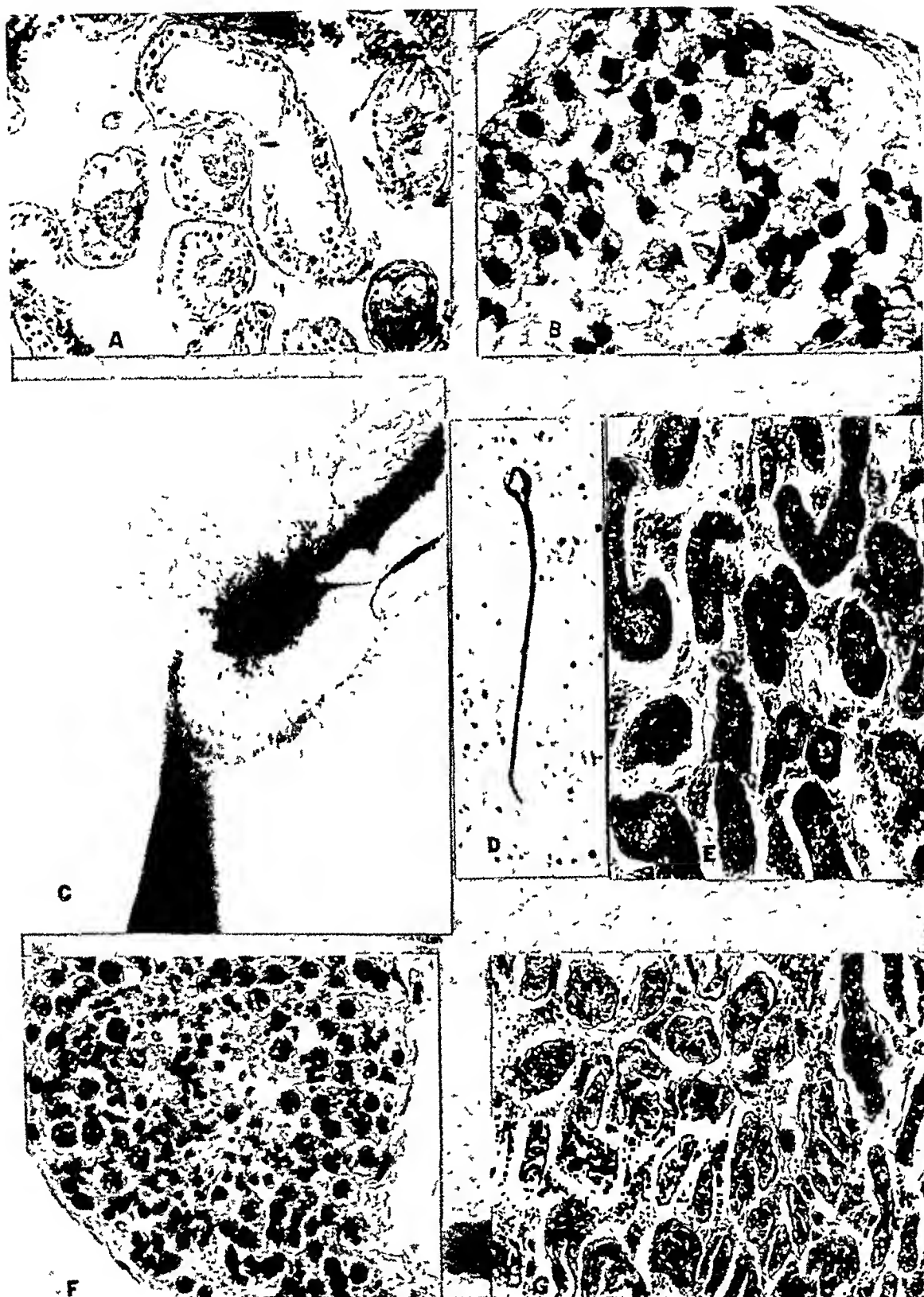


FIG 6—(A) Section of retained testis (right) of a boy of 20, obtained at the time of operation ($\times 180$). (B) Section of same testis six months after scrotal anchorage ($\times 700$). (C) Photograph after bilateral orchiopexy. (D) Photograph of a spermatozoon ($\times 1000$). (E) Section of right testis obtained at necropsy ($\times 180$). (F) Section indicating the presence of spermatozoa ($\times 700$). The condition shown in (E) was present throughout the greater portion of the testis. (G) Section of an area in same testis indicating atrophic tubules ($\times 180$).

TABLE II
EXAMINATION OF SEMEN IN BILATERAL AND UNILATERAL CASES
BEFORE AND AFTER ORCHIOPEXY

No.	Hospital Number	Side	Preoperative Position of Testis	Semen Examination before Operation	Pre-operative Age	Age at Time of Orchiopexy	Date and Nature of Operation*	Cosmetic Result, Position and Size of Testis†	Functional Result: Semen Examination, Amount and Number of Sperm Cells
1	593975 (W.N.)	Bilateral	Both inguinal	Not done	17	11	3/29/30 right orchiopexy 6/30/30 right detached and left orchiopexy	E— $\frac{2}{3}$ adult size 4/8/35 left detached and bi-opsy of both	5/1/35. 7 cc. 3-4 sperm per high power field
2	593497 (P.U.)	Bilateral	Both inguinal	Not done	19	14	6/18/30 bilateral orchiopexy 12/27/30 bilateral detachment	E—testis small $\frac{1}{2}$ normal	5/17/35. 1 cc. Sperm present but scarce
3	617782 (R.N.)	Bilateral	Both inguinal	Not done	23	20	6/13/33 right orchiopexy 8/23/33 right detached and left orchiopexy. 12/22/33 biopsy of both	E— $\frac{2}{3}$ adult size	4/25/35. 3 cc. Sperm present (Fig. 6, E)
4	591998 (G.M.)	Bilateral	Both inguinal	Not done	34	29	2/1/30 bilateral orchiopexy 9/5/30 right excised	E— $\frac{2}{3}$ adult size	5/23/35. 1.5 cc. No sperm cells found
5	58386 (A.K.)	Bilateral	Both inguinal	Not done	19	15	3/23/31 right orchiopexy; left not done yet	E—about adult size	5/22/35. 3 cc. 900 sperm per cu. Mm., i.e., 2,700,000 in specimen
6	62961 (J.M.)	Bilateral	Both inguinal	Not done	21	18	3/7/32 right excised because of torsion; left orchiopexy	E— $\frac{2}{3}$ adult size	5/22/35. Two examinations; none found. This patient had a group of many deep furuncles over the skin of the

THE UNDESCENDED TESTIS

7	40875 (S.L.)	Bilateral	Both intra-abdominal	Not done	24	16	7/29/27 bilateral orchiopexy	E— $\frac{2}{3}$ adult size	Not done yet	lower back and sacrum at the time of examination.
8	626378 (V.H.)	Bilateral	Left inguinal, right intra-abdominal	Not done	19	19	5/3/35 right orchiopexy	Still attached	Not examined since operation	
9	634558 (O.B.)	Bilateral	Both inguinal	Not done	20	20	5/22/35 right orchiopexy	Still attached	Not examined since operation	
10	47368 (S.S.)	Left side	Inguinal	Not done	27	20	2/21/29 left orchiopexy 5/28/29 detachment	E— $\frac{2}{3}$ size of scrotal testis	Not examined since operation	
11	624110 (E.R.)	Left side	Left inguinal, right scrotal	Not done	27	26	3/3/34 left orchiopexy	E— $\frac{2}{3}$ size of scrotal testis	Not examined since operation	
12	630358 (G.G.)	Right side	Right inguinal; Not done left scrotal	Not done	24	23	11/12/34 right orchiopexy 4/23/35 detachment	E—both testes the same size	5/15/35. 10 cc. 46,000 per cu. Mm., i.e., 460,000,000 in specimen	
13	628680 (H.G.)	Left side	Left inguinal, right scrotal with hernia	Not done	25	24	6/21/34 left orchiopexy 4/25/35 detachment and biopsy of both testes	E—both testes the same size	5/28/35. 3 cc. No sperm cells found	
14	47959 (L.K.)	Right side	Right inguinal; Not done varicocele in left spermatic cord	Not done	21	15	4/8/29 right orchiopexy and repair of left varicocele	E—testis small $\frac{1}{2}$ normal	4/25/35. 3 cc. None 5/20/35. 3 cc. None	

* The orchiopexy described by the author was used in all these cases.
† For purposes of brief tabulation, results with reference to position of the testis are designated as E—excellent; G—good; F—fair; and P—poor.
Almost invariably a mobile testis at the bottom of the scrotum was found.

formance of the orchiopexy, an histologic picture not unlike the normal was found throughout the greater portion of the right testis;* and in the left, isolated areas with a mature spermatogenesis were present throughout, though the tubules presenting an atrophic epithelium outnumbered the normal considerably. Even in the right testis there were scattered areas in which the seminiferous tubules were devoid of germinal cells (Fig. 6).

It is eminently significant that out of six cases presenting bilateral failure of descent, after orchiopexy spermatozoa were demonstrated in the semen in four. In the two in which sperm failed of demonstration, the testis† in each instance was of good size (though probably slightly smaller than the average adult normal testis) and freely mobile in the scrotum. In one of these, orchiopexy was performed at the age of 29. When one bears in mind the usual histologic picture of the undescended testis for this age, it is not surprising that scrotal transference at such a late date did not permit of the demonstration of spermatozoa in the semen. In the instance of the other, he was suffering from a fascial plane suppuration originating in a severe furunculosis of the lower back at the time of the semen examination. The unfavorable effect of illness upon spermatogenesis has been elsewhere pointed out.²³

It is particularly noteworthy that in the two patients with bilateral failure of descent in which semen examinations were done *before* operation, no spermatozoa were found. Unilateral orchiopexy has been done too recently in these cases to note the effect of scrotal transference of the testis upon the cytology of the semen.

When one compares the results of the semen examinations‡ in the unilateral cases with those observed in patients presenting bilateral failure of testicular descent, the contrast is striking. Whereas, in the unilateral cases, a swarm of motile cells may usually be seen in any field, one not infrequently must search the preparation diligently to demonstrate the presence of spermatozoa in the bilateral cases. In the unilateral cases 10 and 11 (Table II) 39,000 and 46,000 sperm were demonstrated per cc. of spermatic fluid. The aggregate sperm count for the specimen§ in each instance was respectively

* The greater elapse of time since orchiopexy was done is undoubtedly a prominent factor in the greatly improved character of the germinal epithelium over that obtained by biopsy sixteen months before. Yet the semen examination which revealed only occasional spermatozoa was done only about a week before death.

† Sacrifice of the right testis in the instance of the 29 year old man (Table II, Case 4) was done by choice; in the case of J. M., aged 18 (Case 6) a left sided orchiopexy was done at the same time that a right retained testis was excised because of torsion of the cord and infarction of the testis.

‡ Failure to demonstrate spermatozoa in the instance of the two unilateral cases (12 and 13) is quite understandable for in each instance a biopsy had been made on each testis with the patient's consent at the time of the unilateral scrotal detachment about ten days before the semen examinations were made. The writer has previously called attention to the temporary unfavorable effect upon the histology of the testis of operative manipulation of either testis or spermatic cord.²³

§ Ejaculated specimens; semen examinations on fluid obtained as a result of prostatic massage are particularly untrustworthy, sperm not infrequently being absent in the secretion of ward patients with scrotal testes.

78,000,000 and 460,000,000. A dilution of one to ten with saline was made in a white blood cell counting pipette and several counts were made from each specimen in a regular blood cell counting chamber, after movement in the preparation had ceased (Fig. 7, A and B).*

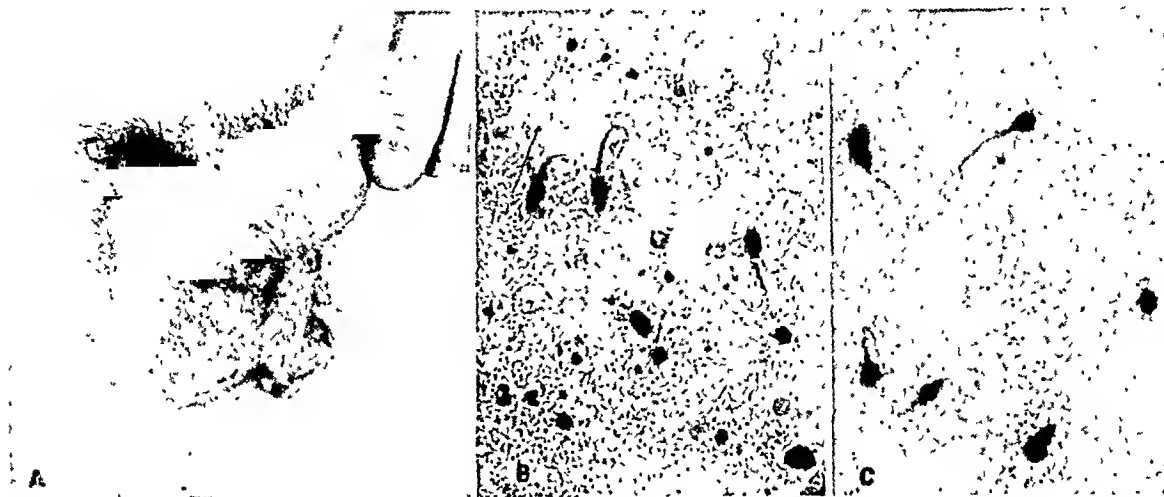


FIG. 7.—(A) Condition after bilateral orchiopexy in Case I. The photographs made at intermediate stages of the operative procedure are shown in Fig. 13, *Surg., Gynec., and Obst.*, vol. 54, p. 219, 1932. (B) Iron hematoxylin stain of a smear of the semen; several spermatozoa can be seen in every field ($\times 700$). A cell count was not done, but sperm did not appear as numerous as in Fig. 7, C in the fresh preparation. (C) The same preparation in a unilateral case after orchiopexy ($\times 700$). (Case 11, Table II. There were 46,000 sperms per cm.

The writer has examined histologically a large number of undescended testes from the dog, pig, horse, and man. In no instance has a mature spermatogenesis been observed.† In retained testes which are just past puberty,

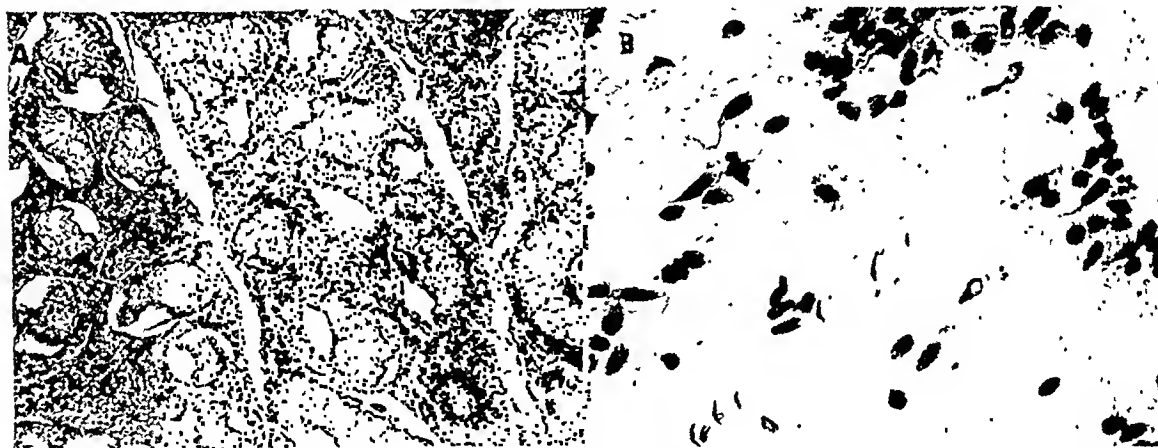


FIG. 8.—(A) The section of a retained testis of an adult pig. (B) Smear from one of the seminal vesicles showing spermatozoa (sperm have also been found on smear of the cut surface of the testis and from the seminal vesicle in an adult pig with bilateral abdominal testes.) It is interesting to see that such a poor germinal epithelium may elaborate spermatozoa.

spermatogonia and spermatocytes can usually be found in large numbers in most of the tubules (Fig. 2, C). With increasing age, these disappear and

* Mrs. Gleva L. Erskine, Medical Technician, kindly made these counts for me and with the help of Mrs. Anna L. Johnson of the laboratory of neuropathology, prepared the sections shown in Fig. 7, B and C.

† The abdominal testes of four horses were made available to me through the courtesy of Doctor Boyd. Though no spermatozoa were found (smears not made) it is my impression that the germinal epithelium of the horse is far better maintained in a retained testis than that of man, pig, dog, or bull.

eventually only the outlines of the tubules with a few Sertoli cells and spermatogonia persist. With the experience in mind of being able to demonstrate spermatozoa in the semen when the tissue removed from the testis (at the time that the scrotal attachment was undone following bilateral orchiopexy) failed to exhibit complete spermatogenesis, observations have been made on pigs with undescended testis at the Armour packing plant in South St. Paul.* Tissues were excised from the following organs in pigs with undescended testes: testis, epididymis, seminal vesicle, prostate, and the bulbo-urethral gland. At the same time, smears were made from the cut surface of testis, epididymis, and seminal vesicle, and after staining, these sections were studied for spermatozoa. These observations will be later published in more detail together with my associates, Drs. George Bergh and Charles Rea. Suffice it here to say that we frequently were able to demonstrate spermatozoa in a smear made from the cut surface of the testis and from the interior of the seminal vesicle, when a study of the histologic sections of the testis revealed a very atrophic germinal epithelium (Fig. 8).† Similar studies on the semen in bilateral unoperated human cryptorchids will probably also occasionally reveal the presence of spermatozoa. I am inclined to believe, therefore, that whereas such cryptorchids are usually sterile, they may occasionally be potentially fecund in the early years after puberty.

However, the improvement afforded the germinal epithelium of the undescended testis by scrotal transference attests the virtue of orchiopexy. An undescended testis properly anchored in the scrotum before atrophy of the germinal epithelium has occurred, is, as has been indicated, capable of a mature spermatogenesis.

Cause of Lack of Uniform Restoration of Germinal Epithelium after Orchiopexy.—Just why such a testis does not produce spermatozoa with the same profusion as the normal is not apparent. The normal testis of the dog elevated to the peritoneal cavity and later returned to the scrotum reproduces again a quite normal germinal epithelium.

Before demonstrating the presence of spermatozoa in the semen of cryptorchids after bilateral orchiopexy, I was inclined to blame the abnormal separation of vas deferens and testis, believing that this anomaly might be associated with obstructions in the epididymis or efferent ductules. This finding is a frequent occurrence in undescended testes (Fig. 9). On three occasions when operating for failure of testicular descent, I have not been able to demonstrate the presence of a testis after carrying the search well into the retroperitoneal region, though a vas deferens in each instance was readily found. It has been adequately shown that ligation of the vas deferens does not cause atrophy of the germinal epithelium. Still, ligation of the excretory ducts of

* Through the courtesy and cooperation of Mr. H. L. Wilkinson, Assistant Manager, and Drs. Thomas and Earl Lowe, physicians to the plant.

† These observations clearly indicate that smears of the cut surface of the testis and from the seminal vesicle are a far more reliable index of the absence or presence of spermatozoa than a study of an histologic section of the testis.

other glands such as the liver, pancreas, kidney, or salivary gland is invariably accompanied by profound histologic changes. I rather felt that this difference in behavior was due to the intervening long coiled tubular duct, the epididymis. Every gland with an excretory duct has a certain secretory pressure. Should the epididymis act as a buffer, one ought to find very low pressures in the vas deferens. Recently my associate, Dr. John R. Paine, and I have measured these pressures in patients having division of the vas deferens before trans-urethral resection of the prostate. Low pressures were invariably found. (Results of this study will be published elsewhere.)

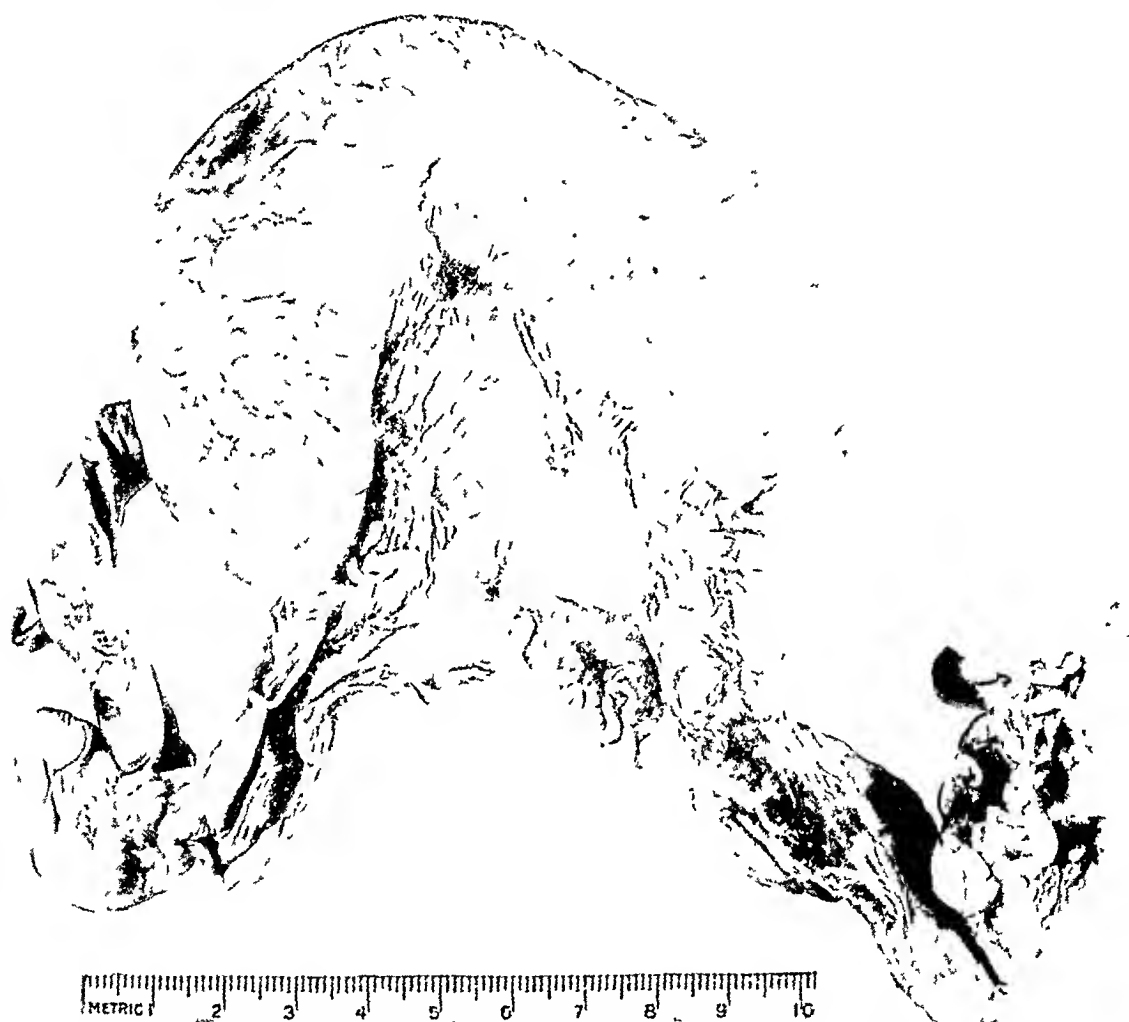


FIG 9—Photograph showing separation of epididymis from the testis in the retained testis of a pig. A similar separation of testes and epididymis is found frequently in human cases, though usually less marked than shown here.

The demonstration of spermatozoa in the semen of cryptorchids effectually puts aside the premise that obstructions are present in the duct system. The suggestion that it may be a hormonal influence upon the germinal epithelium appears to be adequately set aside in the normal condition of the scrotal testis in unilateral cases. The contention of John Hunter that the germinal epithelium of the undescended testis possesses inherent diminished potentialities cannot be gainsaid, but certainly the epithelium of such a testis after scrotal fixation exhibits regenerative properties within certain limits.

That satisfactory scrotal fixation is an important determinant has long been apparent in the size of the testis as correlated with its scrotal position. With the comparative sperm counts in mind observed in unilateral and bilateral cases after orchiopexy, it would appear that some factor other than technical considerations affect the issue. Nevertheless, a good scrotal anchorage performed at the optimal time (just before puberty) and without blood vessel damage affords the undescended testis the greatest promise.

As the years go by, and some of the patients with bilateral failure of testicular descent for whom I have performed bilateral orchiopexy marry, an opportunity will be afforded to note the extent of their potential fertility. Certainly it would appear that paternity is possible in such a patient as A. K. (Case 5, Table II), who has 900,000 sperms per Cm. of semen with only one testis brought into the scrotum. When one contemplates the lavish prodigality with which the reproductive capacities of the normal male are endowed, he must feel stirred by a profound and unfathomable wonder concerning the reasons which prompted nature in this profligate provision.

Practical Considerations.—The results of this study indicate that orchiopexy when well performed is not alone a cosmetic procedure but a functional operation as well, in that it accords the retained testis the most favorable advantage possible for normal development. In bilateral failure of descent (20 per cent of the cases in my experience), the need for the operation may be readily appreciated. The best time for the operation is just before puberty. Inasmuch as pubescent changes become apparent in most boys between 12 and 13 years, the necessary operative procedures, by election, should be done so that the testes will be in the scrotum when the testicular changes incident to puberty occur.*

The operation might well be deferred until 9 to 11 years of age unless an associated hernia or pain prompts its earlier performance. As has been pointed out previously, the testis grows but slightly if at all from birth to puberty. Similarly, the histology of the newborn's testis and that of the child of 11 years, whether the testis be scrotal or retained, are quite identical, and occasionally a testis will descend spontaneously. The frequency of this occurrence, however, cannot be as great as my medical colleague Dr. Drake⁶ has recently indicated. It is to be recalled that he observed 11 patients with undescended testes among 260 boys between the ages of nine and 19 in a St. Paul day school, the average enrollment of which was 140 students. Inasmuch as the usual incidence of undescended testes is considered to be 1 in 500 (based essentially on military practice), it is immediately apparent that he was dealing with a most unusual incidence of the deformity. Even when it is admitted that its occurrence in children may be somewhat more

* It is to be noted (Table II) that in the bilateral cases reported in this paper upon whom semen examinations were made, only one (Case 1) was under the puberty age at the time of operation. A few of the bilateral patients operated upon at an earlier date were not available for purposes of the examination and others were too young to permit of the examination.

frequent than in adults engaged in military service, certainly the incidence of true failure of testicular descent is nothing like as common as Drake⁶ found it in his series. Whereas the usual frequency with which undescended testes† are observed in the whole population is about 0.2 per cent, in males (adults and children) with hernia in whom retention of the testis is considerably more frequent than in the normal population, its incidence is still only one in 80 (Coley^{3‡}) or 1.25 per cent. No mention of hernia is made in any of Drake's cases, yet the incidence of failure of descent is 4.2 per cent—a figure 21 times the normal frequency of the deformity. If the sample was consistent with the findings in a larger group, not more than one case should have been observed among 260 boys. This unusual incidence of so called testicular retention accompanied by subsequent spontaneous descent is explicable only on one basis, *viz.*, that a number of these were instances of so called "spastic retraction of the testis" for which physiologic ectopy or "ectopie en retour" are synonymous terms. Free mobility of the testis of the child appears to be the normal condition, and Hofstätter¹⁰ reports instances of children who at will could draw their testes up into the inguinal canal. The writer has not infrequently been asked to operate for undescended testes in children where subsequent examinations have indicated that the testis is in the scrotum. Of three boys in one family with alleged failure of testicular descent, operation was necessary in only one to bring the testis down. The others were classed by me as instances of physiologic retraction of the testis.

The efficacy of the pituitary-like hormone, antuitrin S or follulutein, in effecting descent in bona fide cases of retention remains to be determined. To surgeons who have had the opportunity of noting at operation the mechanical restraint retarding descent, it is difficult to understand how the administration of a drug can overcome this hindrance. Whereas the normal process of descent of the testis may be accelerated in the macaque monkey as Engle⁷ observed, it is not very likely that true failure of testicular descent will be repaired by its employment. Its use in the type of case reported by Drake would be accompanied by phenomenal success. It is not unlikely, however, that its employment may possess real virtue in infants with retained testes in whom fixation of the testis in its abnormal position is not as secure as in adults. In the larger number of patients operated upon by me for failure of testicular descent, the testis had come out of the external abdominal ring and had migrated up over the abdominal wall (so called superficial interstitial hernia). This portion of the journey, *viz.*, the distance between the top of the scrotum and the external abdominal ring is, as McGregor¹⁵ has pointed out, the most hazardous for the testis. When the impulse for normal migration is still active in the testis, most is to be expected from a drug which enhances this migratory propensity. My associate, Dr. Charles Rea, has treated 14 patients between the ages of four and 24 with testicular retention with antuit-

† A patent funicular process is found in most patients with undescended testes whether actual hernia is present or not.

‡ In a recent discussion Coley³ (Trans. Amer. Surg. Ass'n, vol. 51, p. 22, 1933) says that the incidence of undescended testes in 80,736 cases was 1,357 or 1.65 per cent.

rin S (Parke-Davis), giving usually one cc. (100 rat units) subcutaneously daily for a month. In the instance of a 24 year old boy the testis descended from the inguinal position into the upper portion of the scrotum, but it was later anchored by orchiopexy. Aberle and Jenkins¹ have previously reported somewhat similar experiences with the use of the pituitary-like hormone in effecting descent of the testis.

Unilateral Cases.—In unilateral cases of failure of testicular descent, the manner of dealing with the undescended testis probably would not be so

Fig. 10

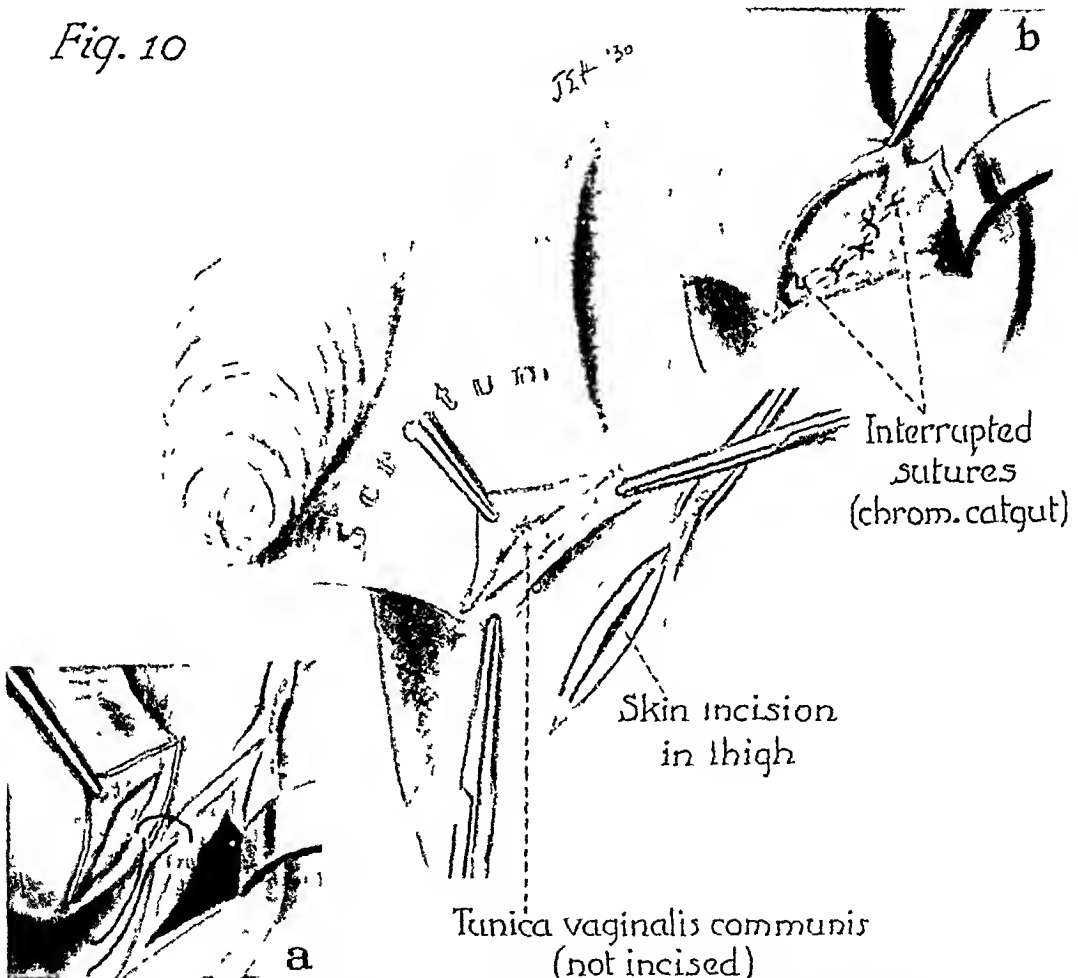


FIG 10—The Technic of Orchiopexy. Establishment of cutaneous juncture between skin of scrotum and thigh (Courtesy SGO, p 54, February, 1932, Fig 10) Since this illustration was made in 1930, the author has found that a cutaneous juncture one third greater in length, as indicated in Figs 11 and 12, insures a more satisfactory union. The posterior row of sutures is of chromic catgut.

readily agreed upon. My own feeling is that where the patient is still young enough to expect improvement in the status of the germinal epithelium by scrotal transference that orchiopexy should be done with the same indications in mind which prompts performance of the operation in bilateral cases. In patients past 30, the testis may be sacrificed without serious loss. The occasion which moves many surgeons to excise the unilaterally undescended testis "willy-nilly" is fear of malignancy. True enough, the retained testis, whether in the abdomen or in the groin, is more likely to become malignant than is the

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Fig. 11

FIG. 11.—From aneur suture, (ooo chromic catgut) are placed in the tunica vaginalis of the testis and are brought down through the tunica vaginalis of the scrotum and anchored to the thigh. The employment of the eye of a probe serves this purpose satisfactorily and obviates the occurrence of a large hole in the tunica vaginalis commensurate with which the testis may protrude, attending the employment of a hemostat to pull the sutures through. It is to be noted that the testis remains in the scrotum.

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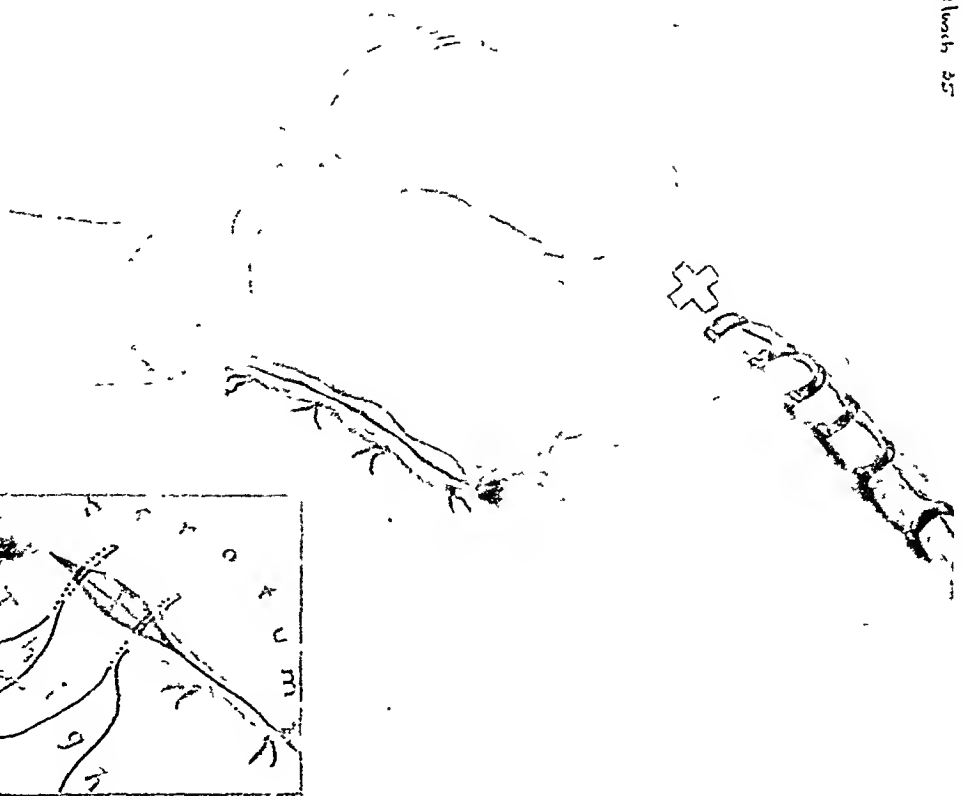


Fig. 12

FIG. 12.—The orchiopexy completed. The sutures shown here are detoured and are usually left until the eighth to tenth day. Prompt healing of this cutaneous junction is almost invariably obtained with careful placement of the sutures shown here. It has been the author's practice to leave this cutaneous junction intact for about four months.

normal scrotal testis (probably about 50 times). Yet malignancy in the testis, whether scrotal or incompletely descended, is decidedly an uncommon occurrence. I am not persuaded that scrotal fixation of such a testis protects against the development of malignancy, for five cases have come to my notice in which malignancy occurred after orchiopexy. If one were to be consistent in his advocacy of the sacrifice of tissue exhibiting an increased disposition to the occurrence of malignancy, he should likewise advise the removal of the normal cervix and breast after their period of essential function is over—a position so absurd as not to warrant an attempt at vindication, even though malignancy of these organs is the most frequent cause of cancer deaths in the female. In this particular, it is necessary to differentiate between precancerous conditions and tissues which exhibit an increased likelihood to malignancy. The undescended testis belongs to the latter class.

In the performance of orchiopexy, a method must be used which will insure a low scrotal position for the testis. Counsellor⁵ has recently discussed at some length the technical features to be considered. After noting the gradual ascent of the testis to a mid or upper scrotal position in many instances in which the Schüller-Bevan^{19, 2} technic was employed, I have practised an operation of my own design which exhibits the advantage over the Torek* operation, that the testis remains in the scrotum and need not be transferred into the thigh. The technic of the procedure is nicely shown in the clear illustrations (Figs. 10, 11, and 12) made for me by Miss Jean Hirsch.

CONCLUSIONS

Observations on patients are reported in which spermatozoa were demonstrated in the semen after bilateral orchiopexy for failure of complete testicular descent. Proof of the presence of complete spermatogenesis in seminiferous tubules of such a testis is also presented. In pigs with retained testes which could be brought into the scrotum by orchiopexy, spermatogenesis was also demonstrated. It is apparent, however, in the human cases as well as in the pigs in which this deformity was corrected that satisfactory scrotal anchorage does not permit of the same uniform and diffuse restoration of mature germinal epithelium which attends scrotal transference of the normal (dog's) testis, temporarily elevated from the scrotum to the abdomen.

Whereas the results here reported would scarcely justify a stock-breeder in having bilateral orchiopexy performed on an animal with a valuable pedigree for breeding purposes, the virtue of orchiopexy in rectifying the sterility of cryptorchids (if still incompletely) warrants the performance of the operation in all suitable bilateral cases in man, for whom the right to procreate, and the blessings of paternity should be preserved inviolate. Apart from the con-

* The technic of orchiopexy known in this country as the Torek²² procedure would more appropriately be termed the Keetley¹²-Torek operation. For though independently conceived and described, their striking similarity is apparent in a comparison of the illustrations of Mr. Keetley¹² and those of Doctor Meyer.¹⁶ Dr. Franz Torek who probably better than any other individual has pointed out the necessity for adequate scrotal fixation in orchiopexy first described his operation in 1909²² at which time he stated that credit for the new method belonged to Keetley.¹² : :

sideration of sterility, which does not concern unilateral failure of descent; the same indications which determine the necessity for operation in bilateral cases should be applied to unilateral testicular retention.

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- ²³ Wangenstein, Owen H.: The Undescended Testis: An Experimental and Clinical Study. Ph.D. Thesis, 1925. Reprinted in Arch. Surg., vol. 14, p. 663, 1927.
- : The Surgery of the Undescended Testis. Surg., Gynec., and Obst., vol. 54, p. 219, 1932.

DISCUSSION.—DR. LEONARD FREEMAN (Denver, Colo.).—I wish to take this opportunity to present a method of holding in place within the scrotum an undescended testis after it has been properly mobilized, which I have tried with satisfaction.

FIG. 13.

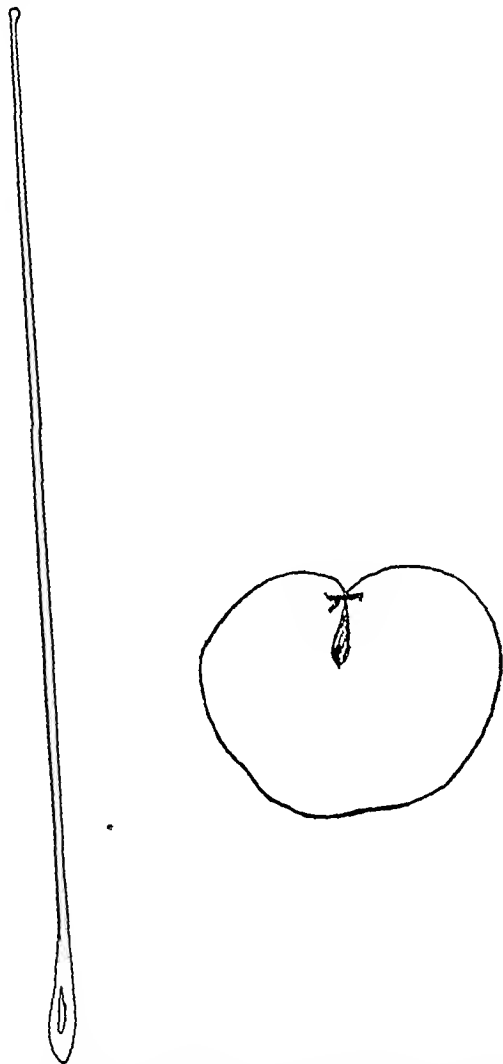


FIG. 14.

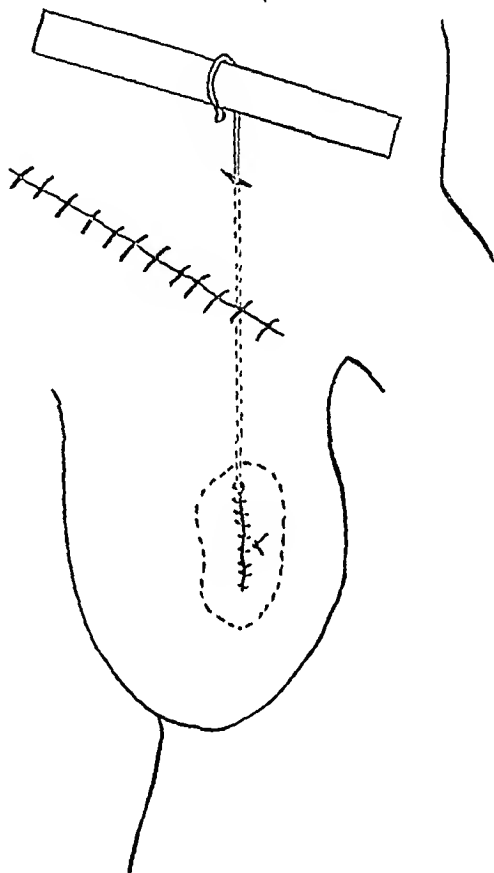


FIG. 13.—Showing probe and infolding of covering of testis to form a pocket for its reception.

FIG. 14.—Showing probe holding testis in position.

In this method the testis is held down by means of a long silver probe passed through a small hole in the skin of the abdomen a short distance above the inner end of the inguinal incision. The lower, or eye end of the probe, which may be looped on itself to increase its bearing-surface, is placed in a bed prepared for it by infolding the tunica vaginalis with chromic gut and for further security a suture of gut is passed through the eye or loop. The upper extremity of the probe is secured to the abdominal skin with a strip of sterile adhesive (Figs. 13 and 14).

The danger of infection is negligible, especially if the hole in the skin fits the probe snugly and an antiseptic dressing is used. (The fact that the probe is of silver also helps.)

At any time after the catgut anchoring suture absorbs, the probe can easily be pulled out from above. The patient can be out of bed promptly.

DR. FRANK TOREK (New York, N. Y.).—You have heard this very interesting paper of Doctor Wangenstein referring to the functional ability of the anchored testis. If we view what happens in the cases that were operated on by orchiopexy, it is very easy to see that the testicle increases in size. Also in many cases the patient himself develops remarkably after the testicle has been brought down, but the question of spermatogenesis is not nearly so simple.

The experiments by Moore, which Doctor Wangenstein has spoken of, are well known, but whether the same is true in the human species we cannot tell except perhaps by one clinical observation that I can cite. That is the case of a man whose testicles had been brought down by another surgeon but had slipped back again. He had been married a couple of years when I first saw him and brought down the testes. The marriage was childless. Eight years after the operation there was a child born to him. That child is now about ten or eleven years old and bears such a striking resemblance to the patient that the paternity can scarcely be doubted.

Of course, you can understand that it is very difficult to come to a conclusion concerning the establishment of spermatogenesis in the human species because we do not know whether those who are capable of procreating after the operation were possibly potentially capable before the operation. The difficulty is particularly great because these cases are usually operated upon in childhood so we cannot get any previous history as to spermatogenesis.

As to the matter of bringing down the testicle by means of a probe, I have no experience, nor have I any experience with the suction method, so I cannot discuss that.

As far as the attachment of the testicle is concerned, Doctor Wangenstein in a previous communication preferred to attach it by way of the dartos, attaching that to the thigh. I prefer to attach the testicle directly to the fascia of the thigh, even without the intervention of its tunica vaginalis. I have always turned that back so the testicle is directly attached to the thigh. The object of that is to give a good chance of getting additional nutrition from a new source.

In that respect it is very similar to the interesting paper we heard yesterday by Dr. Claude Beck, of providing new nutrition to the heart. He attaches the muscle directly to the heart, not to the pericardium, in order to give the heart a new source of nutrition.

Doctor Wangenstein mentioned Keetley. In my first paper on this matter I have given Keetley all the credit for being the first to bring down the testicle and anchor it to the thigh, although he did not attach it directly, but attached it by bringing down the gubernaculum and suturing that to the thigh. He said the gubernaculum is to be divided at a point as high up as possible, then turned down and attached to the thigh, in order, as he says, that the tension on the testicle may not be too great. You can see from that that his operation is a traction method, pulling down by main force, and with this precaution to reduce tension, he still finds it necessary to insist on strong flexion of the thigh in the after treatment.

Another surgeon who has brought down the testis by attaching it to the thigh is Katzenstein. In 1902 he operated, likewise with the employment of

forcible traction, for he says that, as soon as he let it go, it slipped back again. By main force he pulled it through a hole in the bottom of the scrotum and attached it to a flap of skin which he had dissected from the thigh. The operation was successful as far as bringing down the testicle, but it made an ugly appearance after the flap had been cut off from the thigh and sutured to the scrotum.

Another surgeon who performed orchiopexy is De Beule, a Belgian. He reported two cases in which he had attached the testicle directly to the fascia of the thigh. This attachment, however, was also done by the traction method. He describes how very tensely stretched the cord was.

There are points in De Beule's article of November, 1906, which for various reasons fail to be convincing. Thus, he claims priority over Keetley because the first of his own two cases was operated on in 1904, whereas Keetley's paper appeared in 1905. But if De Beule read Keetley's article, he ought to have known that at that time Keetley had already operated upon more than 25 cases. Moreover, Keetley had already shown cases in 1894 and had published them in the *Lancet* in April, 1894. (I may also say, in passing, that I had already shown some of my cases at the New York Academy of Medicine before De Beule's article appeared. Furthermore, in De Beule's article there is an illustration of his second case, three and one-half years old, a unilateral orchiopexy, recently performed, for the gauze dressing of the posterior suture is still in place, showing the scrotum of the attached testicle to be very well developed, not stretched but hanging, although the picture was taken shortly after the operation, and the other testicle and scrotum on the unoperated side exceptionally large. It almost looks as though this might have been a testicle that would have come down by itself. But at any rate, the priority of anchoring the testicle to the thigh decidedly belongs to Keetley and not to De Beule or Katzenstein.

DR. FRANK K. BOLAND (Atlanta, Ga.).—I would like to call attention to a non-operative method of treating the undescended testis as practiced by my urologic friends, Doctors Ballenger, Elder and McDonald, in Atlanta. The method was instituted by them 15 years ago to develop the size of the penis. That the treatment would also prove effective for undescended testis did not at first occur to them, but it soon became evident that while the suction which was employed enlarged and pulled down the penis and scrotum, it had the same effect on an undescended testis. The treatment is used when hormones have failed, or as an adjuvant to hormones. The apparatus consists of a glass cylinder somewhat larger than the barrel of a 100 cc. syringe. A rubber ring surrounds the open end of the cylinder, while to the small nozzle at the other end is attached a rubber tube which is connected with a water pump. The patient's pubes is well soaped, and the penis and scrotum enclosed in the cylinder which is pressed airtight against the pubes. The water pump is supplied with an indicator which shows the amount of vacuum that is generated in the cylinder, the average suction used being equivalent to from five to 30 pounds. The best indicator, however, is the amount of vacuum which the patient can endure comfortably. Treatments usually are given two or three times a week, for from two to ten minutes on each occasion. Suction causes the parts to enlarge and elongate three or four times their usual size, the vacuum being maintained from five to 20 seconds with each suction. The vacuum is immediately discontinued by a turn valve at the distal end of the cylinder, or by a foot control. As soon as the patient feels that he has all the pulling he can stand, the vacuum is cut off, another suction being instituted a few moments later.

Twenty-six patients have been treated in this manner, of ages from four to 16. One of the best results occurred in the 16 year old boy, who is now a doctor, married and raising a family. However, the most successful cases have been in boys from six to eight years old. The majority of these patients have had perfect results, the penis, scrotum and testes being full size, and the testes being drawn well down in the scrotum. I have seen two such satisfactory results. The length of treatment has varied from one to six months. The patients not completely cured either were too old or did not continue the treatment long enough. It is believed that this vacuum method is capable of correcting undescended testis in any boy of the right age. It is no doubt true that the testis may have descended in some of these patients without treatment. One of the authors of the method thinks testes in the abdominal cavity should first be transplanted into the inguinal canal by operation, and then subjected to vacuum therapy; while another author is of the opinion that the testis can be drawn down by suction, no matter how high it may be. A striking outcome of the procedure is that not only are the external genitalia made normal, but the feminine characteristics, which so many of such patients display, are made to disappear. They lose weight, and the hips and breasts become masculine in contour. No serious trauma by the treatment has been noted. One patient developed a slight ecchymosis at the base of the penis, which lasted only a few days. I inquired if such manipulation of the genitalia ever led to masturbation, but was informed that no such sequel has been reported.

DR. ARTHUR D. BEVAN (Chicago, Ill.).—I believe the successful handling of undescended testis is a matter of anatomy, a very careful study at that. In undescended testis, in the operation, one must free the testicle perfectly by the removal of the transversalis fascia, the vaginal process of peritoneum, the cremasteric muscle, and fascia, and intercolumnar fascia, so that you really free the testicle completely from the coverings of the cord.

In that way you can obtain lengthening of the cord, depending upon the age of the child or individual from two to five inches (Fig. 15). Where you can obtain sufficient lengthening so that the testis can be placed in a pocket made in the scrotum without any tension, you can secure admirable results without any fixation to the thigh or any other artificial means (Fig. 16). In order to retain the testis in the scrotum, a fine suture should be placed at the neck of the scrotum in front of the cord; care should be taken in placing this suture so that it can in no way interfere with the blood supply of the testis.

There is one point that we have employed in the technic which is interesting and important. For about five years, we have been passing a needle through the strong fibrous coat of the testis, and double threading a piece of catgut or, you can take silk, if you please, and after you have made a large pocket in the scrotum, pass a straight needle on a director through the bottom of the scrotum (Fig. 17), carrying this catgut with it so you have a guide, held by an assistant, holding the testicle well down in the pocket while you close the neck of the scrotum (Fig. 18). After the operation is completed this temporary guy rope is removed.

In regard to antuitrin, it seems to me we have to keep our feet on the ground in a problem of this kind—it is a common sense problem. What in the world do you want to use it for even though you can produce an early development of the testis in a young child? Why should you give a child of five or six or eight years of age a hormone that would develop the testicle? As a matter of fact, I think in no cases of pure, undescended testis, even though

you can increase the size of the testis very considerably, would you bring the testicle down except in a special class of cases which I have described, which indeed forms a very considerable class. At least in a quarter of the cases that are sent to us to operate upon are not undescended testis cases at all. If you run your fingers down the groin in these cases, you can push the little testicle

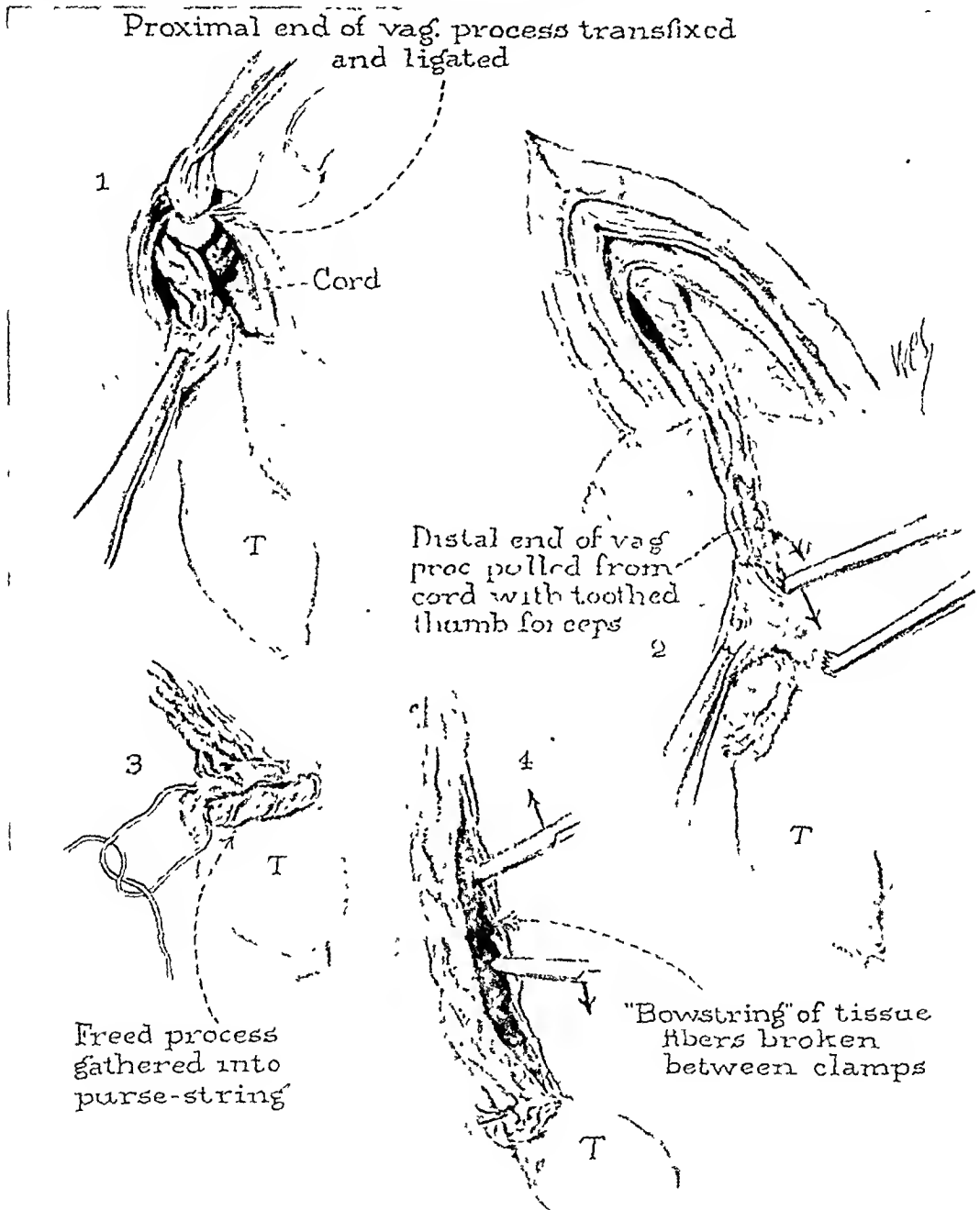
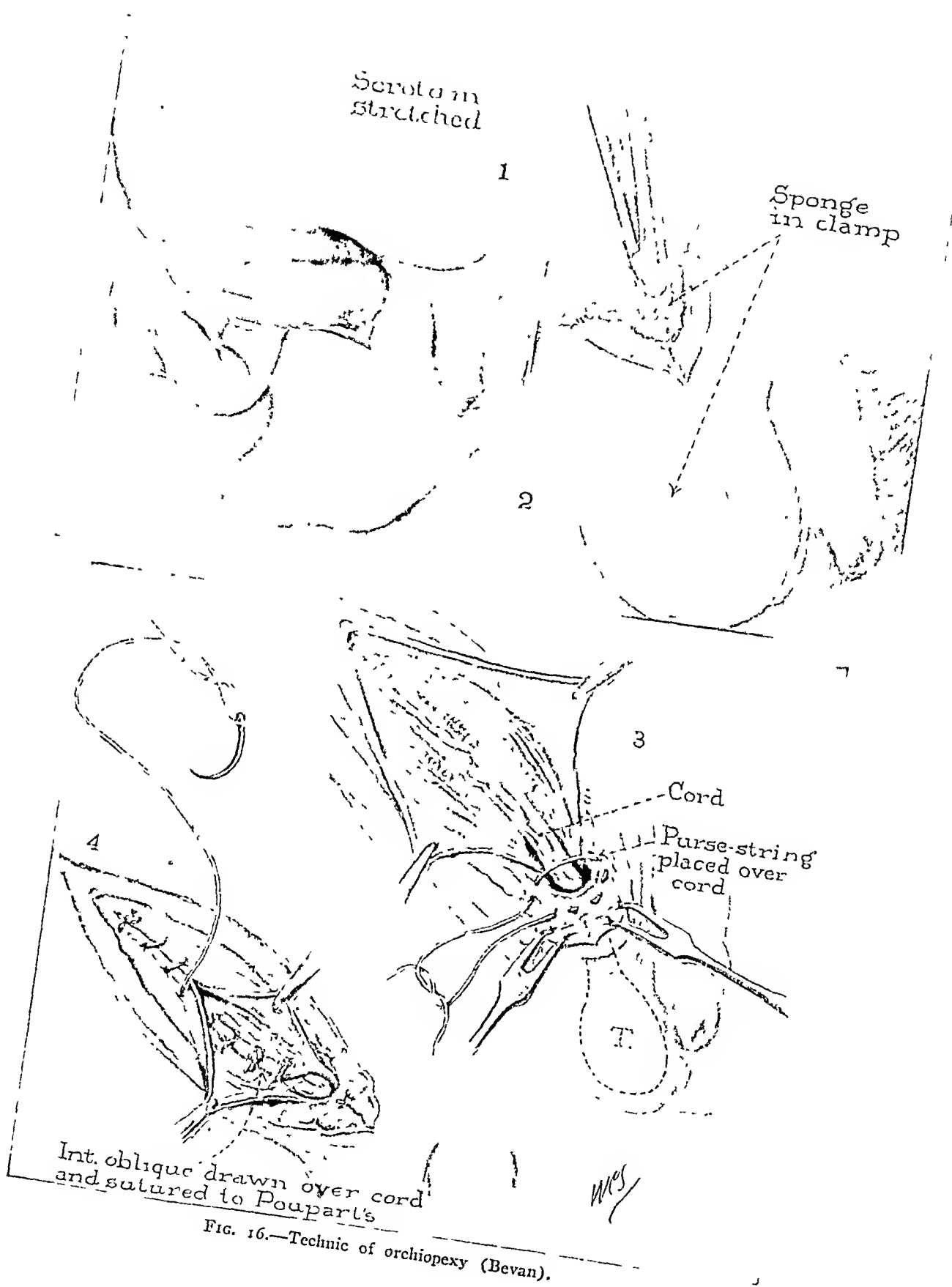


FIG. 15.—Technic of orchiopexy (Bevan)

right into the scrotal pocket. When you take your fingers off, they return; but at puberty with the enlargement of the testis they drop down into the scrotum of their own accord. We have had a large experience with this type of case, at the age of puberty, with the enlargement of the testis, they drop down into the scrotum and develop normally.

THE UNDESCENDED TESTIS



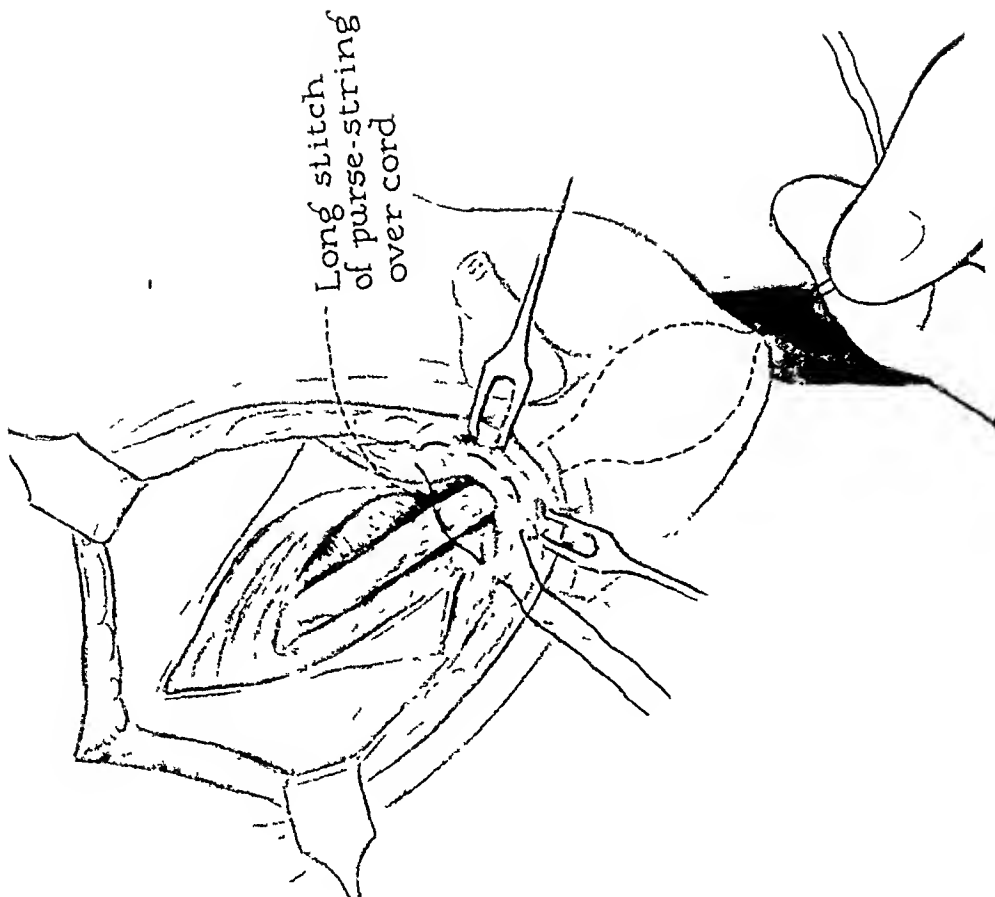


FIG. 18.—Technic of orchiopexy (Bevan).

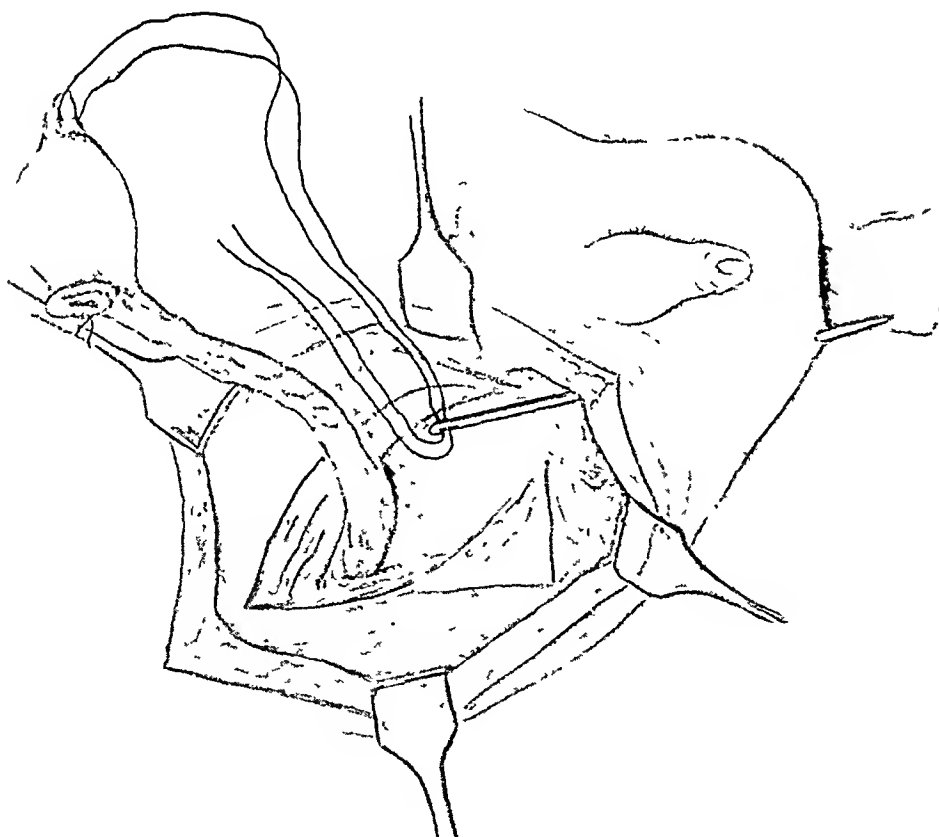


FIG. 17.—Technic of orchiopexy (Bevan).

DR. WILLIAM B. COLEY (New York, N. Y.).—The subject of undescended testis is one that has interested me since 1893 when I did my first operation. I am quite in accord with what Doctor Bevan has already said. I do think it is an anatomic problem and while I am willing to admit the results of bringing the testis and fixing it in the thigh are somewhat nearer ideal than the results following the operation Doctor Bevan described in the late nineties and 1901 and 1903, I do not believe that the results of this method are so much inferior to that of Torek as to warrant adopting the latter as a routine measure.

I believe the great majority of cases of undescended testis, if operated upon at the proper time, can be put in the bottom of the scrotum, and a very large number will stay there; some will retract to the middle of the scrotum, and some to the external ring. I do not believe that spermatogenesis has anything to do with the malposition of the testis. This is an opinion that I expressed in 1914 at the meeting of the American Surgical Association before which I reported 414 cases of operation for undescended testis, of which 40 were in adults.

Unfortunately, few surgeons attempt to follow up cases that have been operated upon for undescended testis. In a series operated upon by Doctor William A. Downes and myself at the Memorial Hospital, we traced 125 cases from two to 20 years, which is the longest period ever traced. While the results, in our opinion, were not perfect, they were very fairly satisfactory: there were no deaths in the entire series, and no return of the potential hernia that always exists.

As to the frequency, I was quoted correctly; *i.e.*, one sixty-fifth of one per cent. I made a study many years ago of 80,000 cases of inguinal hernia in the male, observed at the Hospital for Ruptured and Crippled, as regards relative frequency of undescended testis, and in this number I found 1,757 undescended testes.

Taking operative statistics, in 1908 in 4,000 cases of inguinal hernia in the male, we operated upon practically $7\frac{1}{2}$ per cent of undescended testis; in adults, the percentage was only 4.7. But I do not believe the question of the functional value of the testicle depends at all upon the place where the testicle is found or put. I do not think you can tell anything about it by animal experimentation either. The only way of telling whether the undescended testis is of functional value is to study the history of the cases you have operated upon for double undescended testes.

I have had two cases of double undescended testes in both of which the patients become fathers of children. In both, the testes were brought down into the scrotum in the way outlined by Doctor Bevan, and not attached to the thigh. My feeling today is, that while the Torek operation is an admirable one and usually gives ideal results, it is unnecessary to perform such an extensive operation in the great majority of cases, especially in children.

Regarding the age at which to operate: we formerly operated upon children as young as four or six years old; but we later came to believe that it was unwise to operate under 12 years of age because we learned by observation that in a large number of cases the testis will come down voluntarily if given time, thus avoiding an operation.

DR. OWEN H. WANGENSTEEN.—This is obviously a very broad subject and time will afford me opportunity to comment only briefly on a few points in the discussion. The novel suggestion of Doctor Boland is very intriguing. I am inclined to believe, as Doctor Bevan so well put it, that a rather large number of patients with alleged failure of testicular descent, cured of their deformity by non-operative methods, are afflicted with a condition known as

spastic retraction of the testis rather than true failure of descent. Any one who has done a number of operations for the correction of incomplete testicular descent cannot escape the impression that the mechanical element is an important one in hindering the spontaneous descent of the testis into the scrotum when once it has become arrested in the groin. At operation, almost invariably, it is found necessary to remove many little fibrous kinks and bands from about the spermatic cord before the testis can be brought into the scrotum. I have seen no instance at operation in which a pull upon the testis and spermatic cord by the surgeon would permit the testis to be placed in the scrotum. A sage renowned for his wisdom once said: "To every thing there is a season, and a time to every purpose under heaven." Though I admit considerable trust in the principle of suction, as some of you may know, I cannot believe that this is a place for its employment.

With reference to the remarks of Doctor Torek, I should only like to remind you that as far as is known, the blood supply to the testis in instances of incomplete descent is quite adequate. I venture to suggest that were the blood supply of the testis deficient that mere placement of the testis in the thigh would not permit it to eke out of this new potential source sufficient nutriment to enable the testis to repair the deficiency in its germinal epithelium.

It is my belief, supported by experience, that some means of adequately fixing the testis in the lower part of the scrotum is a highly essential feature of the operative procedure of orchiopexy. If uniformly good results are to be had, adequate fixation of the testis must be afforded. The facility with which the testis may retract after orchiopexy, when not fixed, is certainly a matter of common knowledge and experience. The elements to which responsibility may be attributed for the retraction are the components of the spermatic cord and the dartos muscle of the scrotum. The cremaster muscle is invariably cut away in the operative procedure, hence it can play no rôle. The vas deferens is relatively inelastic. The blood vessels, on the contrary, are quite elastic and are no longer than they have to be. I believe that the blood vessels together with the dartos muscle may be held accountable for retraction of the testis after orchiopexy when testicular fixation is not employed. As to the means of fixation employed, it must be a method which will hold the testis down for some time. In my own experience, a suture fastened to the testis and anchored to the thigh is inadequate; within a few months the testis retracts to the upper portion of the scrotum.

A well tempered doubt, as manifested by Doctor Coley is of the greatest virtue in any experimental problem. When, however, he affects to deny any relationship between spermatogenesis and an aberrant position of the testis, he denies the facts. That the normal testis becomes aspermatic when elevated out of the scrotum has long been known; that its return to the scrotum restores spermatogenesis has likewise been established. The results of this study indicate that improvement in the germinal epithelium attends satisfactory scrotal anchorage of the undescended testis in man as well as in the pig. It is to be freely admitted, moreover, that restoration of a mature spermatogenesis does not occur in the same measure, after orchiopexy for undescended testis, as attends return to the scrotum, of a normal testis, previously elevated to the abdomen. The reason for this difference remains yet unexplained, and may well lie, as Doctor Coley implies, in an inherent diminished capacity of the undescended testis.

SUBACUTE STREPTOCOCCUS VIRIDANS SEPTICEMIA

CURED BY THE EXCISION OF AN ARTERIOVENOUS ANEURYSM OF THE
EXTERNAL ILIAC ARTERY AND VEIN

WILLIAM F. RIENHOFF, JR., M.D., AND LOUIS HAMMAN, M.D.

BALTIMORE, MD.

FROM THE MEDICAL AND SURGICAL CLINICS OF THE JOHNS HOPKINS HOSPITAL, BALTIMORE, MD.

ON JANUARY 21, 1935, a young man was referred to us for examination who had been ill with fever for six months. A brief story of the illness and a summary of the results of the examinations which were made follow:

CASE REPORT

Unit History No. 60223, Mr. J. A. W., an oil salesman, 35 years of age, entered the Johns Hopkins Hospital, January 21, 1935, complaining of weakness, loss of weight and fever of six months' duration. Before the onset of this illness he had always been a healthy man. He had had several of the minor infectious diseases of childhood. At 26 the tonsils had been removed. The only point of interest relative to the recent illness was that at 18 years of age, May 18, 1918, the patient had accidentally shot himself with a 22 caliber rifle, the bullet penetrating the abdomen just above Poupart's ligament. Immediately after the accident, the patient was able to walk about 50 yards. He had a very severe burning sensation in the right leg and bled profusely from the bullet wound. His companions placed a tourniquet around the thigh which stopped the profuse bleeding, but the patient had lost so much blood that he fainted repeatedly while being transported eight miles to the nearest hospital. That evening he was operated upon by Dr. A. M. Willis at the Virginian Hospital in Richmond. After the operation he was informed that the bullet had torn a hole in the two large vessels which supply the right leg, and had established an arteriovenous communication between them. An extensive retroperitoneal hemorrhage had occurred. The injury was followed by pronounced swelling of the right leg and for a while the patient was completely disabled. After a few weeks, however, the swelling disappeared and gradually he was able to use the leg more and more until finally at the end of two months he could walk about without the use of a cane. During the next six months there was occasionally some swelling of the ankle in the late afternoon and evening. If the patient exerted himself unusually, cramp-like pains in the leg would come on which, as time progressed, became less pronounced. All symptoms of the injury had disappeared at the end of a year excepting some nocturnal palpitation of the heart, and the consciousness of a vigorous pulsation in the right lower quadrant of the abdomen. There had never been any dilatation of the veins of the right thigh, leg or foot; no changes in the skin; none in the bones by roentgenologic examination; and the length of the right and left extremities was the same. In 1932 the patient was examined by Doctor Caravati who found no abnormality except the presence of an arteriovenous aneurysm in the lower right quadrant of the abdomen together with moderate enlargement of the heart associated with a rapid pulse, varying from 100 to 120 beats per minute.

The patient's recent illness dated from July, 1934, when he began to feel listless and generally indisposed. His temperature was taken and it was found that each afternoon it rose to about 100°. A little later his appetite failed and in a short time he lost 30 pounds in weight. The patient's symptoms were thought to be the result of a mild throat infection. However, although the local manifestations promptly cleared up under treatment, the fever and lassitude persisted. In September he had a number of severe chills and the possibility of malaria was considered and he was given large doses of quinine.

Under this treatment the temperature dropped to a lower level but the patient's general condition did not improve. At the end of September he was so weak and miserable that he went to bed and remained there up to the time of his admission to the hospital.

During the intervening four months the condition had been very thoroughly investigated but no satisfactory diagnosis had been reached. The possibility of amebic dysentery was considered and he was treated with emetine, but without benefit. The fever persisted and he continued to lose weight and strength. Doctor Caravati took charge of the patient in October, 1934. At that time the physical examination showed emaciation, pallor, enlargement of the liver and spleen and the presence of the arteriovenous aneurysm. Agglutination tests with strains of *Brucella* were negative. With the typhoid bacillus, agglutination occurred in a dilution of 1:200. The patient had received prophylactic typhoid vaccine about seven years before. On a number of occasions occult blood was found in the stools. The blood showed a mild secondary type of anemia. During October there was a slight leukocytosis but this soon disappeared and later the leukocyte counts varied from 6,500 to 9,000. Roentgenographic examination of the gastro-intestinal tract revealed no abnormality. Fourteen blood cultures had been made and all were reported negative.

Physical Examination.—Temperature, 101°; pulse, 110; respirations, 22; blood pressure, systolic 110, diastolic 60.

The patient was an undernourished man with a sallow, anemic complexion. He had evidently lost much weight and his appearance showed evidences of prolonged illness. Aside from his weakness and lassitude, he otherwise felt well. He had no pain or other local discomfort. No petechial spots were noted in the mucous membranes or in the skin. The eyes were normally prominent. The pupils were equal; they reacted actively to light and accommodation. Inspection of the fundi revealed no abnormality. The teeth were in good condition. The pharynx showed nothing remarkable. The tonsils had been completely removed. There was no enlargement of any of the superficial lymph nodes. The thyroid was not enlarged. The chest was rather long and thin with a narrow costal angle. It was symmetrical and the movements were equal on the two sides. The percussion note over the lungs everywhere was resonant and the breath sounds were vesicular. No râles were heard. The area of cardiac dulness was not enlarged. The heart sounds were clear and of normal quality except for a loud, systolic murmur in the pulmonary area. The pulse was regular, of high amplitude and a little quick though by no means collapsing in quality. The abdomen was normal in appearance. The walls were soft and relaxed. The edge of the liver could be felt about a finger's breadth below the costal margin; the border was rounded and the organ of normal consistency. The edge of the spleen was easily felt about a finger's breadth below the costal margin and was a little tender. In the right lower quadrant there was an intense, continuous thrill on light palpation which was associated with marked excursion of the iliac vessels. On deep palpation the difference between the size of the iliac vessels on the right compared with the normal vessels on the left was very striking. The vessels on the right side were many times larger than on the left. By exercising firm pressure it was possible to obliterate the fistulous opening, thereby causing a cessation of the continuous thrill. It was interesting to note that occlusion of the opening did not bring about perceptible slowing of the pulse rate,* indicating that the fistulous communication was probably a small one. A hard, bony-like structure could be felt about the mass which the roentgenogram proved to be the calcified wall of the encysted varicose aneurysm. There was vigorous pulsation in

* Previously called Branham's sign, but this phenomenon was first described by Nicholadoni, Phlebarteriektasie der oberen Extremitat. Arch. f. klin. chir., vol. 18, p. 252, 1875. Branham in 1890 made an independent observation of this reaction in traumatic arteriovenous aneurysm. Cf. Dr. Dean Lewis (1) Congenital Arteriovenous Fistulae. Lancet, September 20, 27, 1930; and (2) The Bradycardiac Reaction and the Cardiac Changes in Arteriovenous Aneurysms. Emanuel Libman Anniversary Volumes, 1932. International Press, New York.

the external iliac artery just above Poupart's ligament and in the femoral artery below. A strong pulsation was easily felt in the dorsalis pedis and posterior tibial arteries. Auscultation over the aneurysm revealed the classic machinery-like to and fro bruit which was markedly diminished in intensity by deep pressure on the upper portion of the external iliac artery. There was no evidence of the development of a collateral circulation about the hip or thigh. There were no varicosities of the veins distal to the point of the fistulous communication. There was no swelling or edema of the soft parts of the thigh, leg or foot. Blood pressure readings:

	Systolic	Diastolic
Right arm	120	55
Left arm	125	45
Right thigh	60(?)	40(?)
Left thigh	120	55

The skin temperature of the right and left lower extremities was essentially the same. When deep pressure was made over the external iliac artery above the fistulous communication there was marked diminution in the blood flow through the femoral artery, but no difference occurred in the appearance of the skin of the right extremity or in its temperature. These observations confirmed the impression that the fistulous communication between the external iliac artery and vein must be a small one. Since there was no change in the temperature or appearance of the skin following deep pressure over the upper part of the external iliac artery, we concluded that the collateral circulation which had developed would be sufficient to prevent serious embarrassment of the blood supply to the extremity should the external iliac artery above the fistula be permanently occluded. The extremities otherwise showed no abnormality, no arthritic manifestations, no clubbing of the fingers. The deep reflexes were normally active.

Laboratory Examinations.—Blood count: hemoglobin, 68 per cent; red blood cells, 3,650,000, white blood cells, 10,000. Differential: Polymorphonuclear neutrophils, 65 per cent; lymphocytes, 32 per cent; monocytes, 3 per cent. Wassermann reaction on the blood serum negative. Van den Bergh test negative.

Agglutination tests: *Bacillus typhosus* positive up to dilution of 1:320. Paratyphoid B positive up to dilution of 1:320. Paratyphoid A., Shiga's bacillus, Flexner's bacillus, Brucella's abortus—all negative.

Blood cultures: 1/23/35, *Streptococcus viridans*, 28 colonies per 1 cc. of blood. 1/29/35, *Streptococcus viridans*, 20 colonies per 1 cc. of blood. 2/6/35, *Streptococcus viridans*, 49 colonies per 1 cc. of blood.

Urine: Specific gravity ranged from 1.010 to 1.020. Contained neither albumin nor sugar. A few pus cells in the sediment. No red blood corpuscles or casts. Urine culture: No growth. Stool: No gross blood or mucus. Benzidine test negative. Microscopically some undigested vegetable material, otherwise negative. Intracutaneous tuberculin test: No reaction.

Röntgenologic Examination.—Abdomen.—An elliptical body clearly defined by calcified walls overlying sacro-iliac joints. The appearance of this structure is compatible with the diagnosis of arteriovenous aneurysm. A bullet is located opposite the third lumbar vertebra on the right side. Chest.—Increase of the shadows about the middle border of the lungs due probably to chronic passive congestion. There are no areas of bronchopneumonia. The heart seems not to be enlarged. Tele.—M. R. 5.5, M. L. 9, A. 5.5, T. 28.5.

Electrocardiogram.—Rate 115. Rhythm sino-auricular. P-R interval .14, QRS duration .08. Normal sinus rhythm. T I and II upright. T III inverted. Ventricular complexes are sharply defined. Sinus tachycardia.

DISCUSSION.—These observations demonstrated conclusively that the patient was ill with *Streptococcus viridans* septicemia but it was not clear

precisely where the infection was located. It is well known that the *Streptococcus viridans* often invades the blood stream, sometimes even in large numbers, when there is an acute septic infection, for instance, a severe acute sinusitis. However, under these circumstances the septicemia is brief, for the organisms at once disappear from the blood when the acute infection subsides. Certainly there was nothing in the situation which then held our attention to encourage the sanguine hope that the septicemia might be such an acute and transient one. Quite otherwise, for all the facts (the long duration of the illness, the persisting fever, the anemia, the enlargement of the spleen, the repeatedly positive blood cultures) demonstrated that there must be a focus of infection having direct access to the blood stream and continuously discharging bacteria into it. When we observe a clinical picture so characteristic as this one was we conclude that the focus of infection is in the heart, because wide experience has taught us that under these circumstances it is nearly always situated in that organ and, save for rare exceptions, upon the valves. Therefore we confidently expect to discover the unmistakable evidence of a valvular lesion and if the infection has existed for some time our expectation is seldom disappointed.

The remarkable thing about the present case was that the anticipated evidence of a valvular defect was completely wanting. It may be that the heart was a little enlarged (the measurements of the teleroentgenogram being a trifle more than half the transverse diameter of the chest) but some enlargement might be expected to follow as a result of the circulatory alterations caused by the arteriovenous aneurysm. The heart sounds were clear and of normal quality except that there was a systolic murmur at the pulmonary area. In the presence of anemia and long-continued fever it would be noteworthy if a systolic murmur did not appear at the pulmonary area.

Being convinced by repeated examinations that the infection was not located upon the heart valves, two possibilities suggested themselves (a) that the vegetations were upon the endocardial surface of the chambers of the heart or (b) that they were situated within the arteriovenous aneurysm.

The occurrence of vegetations upon the endocardial surface of the auricles or ventricles is one of the common observations of the pathologist. Almost every case of subacute bacterial endocarditis will show them, where they have extended directly from the diseased valves or where they have become implanted from the infected valve which, floating to and fro, has rubbed against the endocardial surface. These are familiar observations, but it is another matter to ask whether bacterial vegetations upon the inner surface of the chambers of the heart ever occur as primary foci of infection, that is, when there is no valvular disease or congenital defect. No note of such an occurrence can be found upon the pathologic records of the Johns Hopkins Hospital and both Dr. W. G. MacCallum and his associate, Dr. A. R. Rich, tell us that they have never seen an instance of it. Therefore, if it ever happens it must be a great rarity. The fact that no evidence was noticed of embolic phe-

nomena in the general circulation was a point against the infection being located within the left side of the heart.

Unfortunately the localization of bacterial vegetations within an arteriovenous aneurysm must occur almost as uncommonly as their isolated growth upon the endocardial surface of the heart. A review of the literature failed to disclose a reported example of the condition. Nevertheless there are many observations which led us to believe from analogy that bacteria might settle and grow within an arteriovenous aneurysm. We refer to the observation of *Streptococcus viridans* vegetations about the orifice of a patent ductus botalli or at the site of coarctation of the aorta. We recall also an instance in which bacterial vegetations were situated within an aortic aneurysm. These are clear demonstrations that bacteria often lodge and grow upon the intima of the aorta at points where the vessel is constricted or its walls damaged by disease. From mechanical standpoints an arteriovenous aneurysm is very similar to an open ductus botalli.

These considerations led us to believe that in the present case, in all probability, the *Streptococcus viridans* had settled and grown within the arteriovenous aneurysm and from this site of advantage continuously poured bacteria directly into the blood stream. Should this be the case then, we reasoned, the septicemia might be cured and the patient restored to health by excision of the aneurysm. The possibility of gangrene of the leg setting in after ligation of the right external iliac artery was discussed, but upon this point the surgical opinion was entirely reassuring. The *Streptococcus viridans* is an organism of mild virulence. The view generally held is that it would disappear at once from the blood stream were there not present a focus from which fresh bacteria are constantly discharged into the circulation. As we have already said, the sudden flooding of the blood stream with *Streptococcus viridans* in connection with an acute infection which soon subsides is relatively an innocuous affair.

As matters then stood the outlook for the patient under conservative treatment was almost hopeless. Study of anatomic specimens teaches that many patients get well of bacterial endocarditis. This anatomic evidence, however, is so glaringly in contrast to clinical experience that we are forced to conclude that most of those who recover must have had such mild symptoms that the infection passed unrecognized. When the typical clinical manifestations of subacute *Streptococcus viridans* septicemia are once fully developed recovery does not often follow. Therefore it was more than likely that the patient would die were no radical measures undertaken.

On the other hand, excision of the arteriovenous aneurysm, should the infection be located there, held out the bright prospect of cure. It seemed to us that to perform the operation was risking little in the hope of very great gain. The situation was plainly and fully explained to the patient and his wife. Both enthusiastically chose operation.

Operation.—As the illustration (Fig. 1) shows, the enormously dilated right common and external iliac arteries, overlain by the right ureter, presented in the operation wound.

To the left and coursing along the medial side of the external iliac artery, the very much dilated and thin-walled external iliac vein joined with the internal iliac to form on the

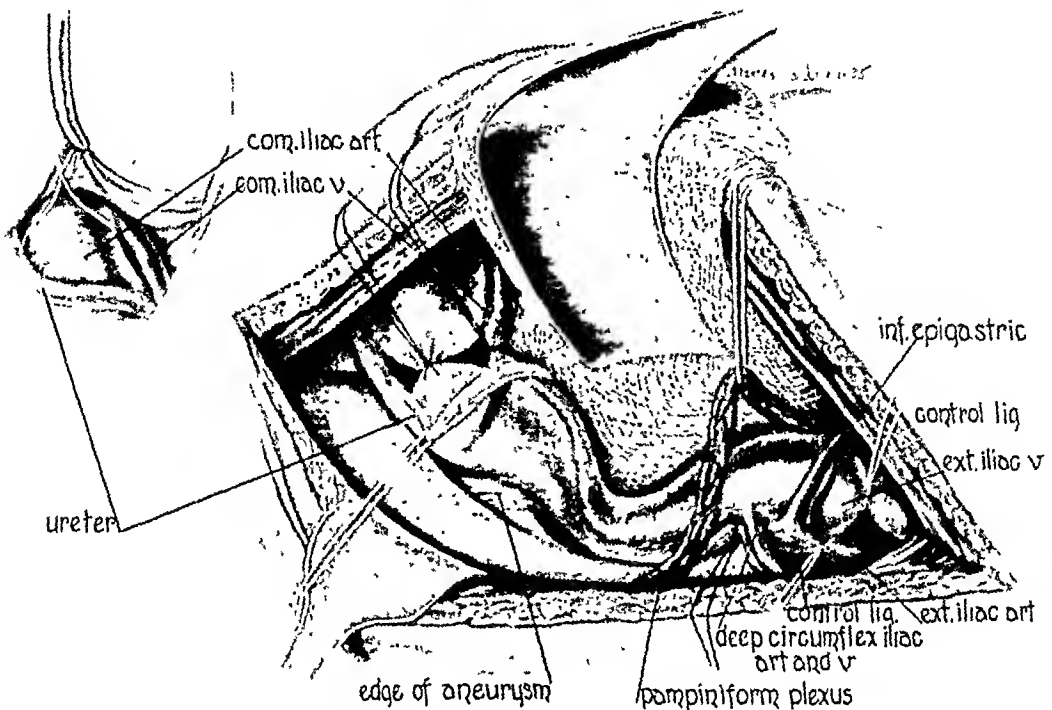


FIG. 1.—Drawing, made at operation, of the dissection of the arteriovenous aneurysm between the external iliac artery and vein. Control ligature about external iliac vein was used as permanent ligature, but the control ligature about the femoral artery was removed, a permanent ligature being placed proximal to the departure of the deep circumflex iliac artery.

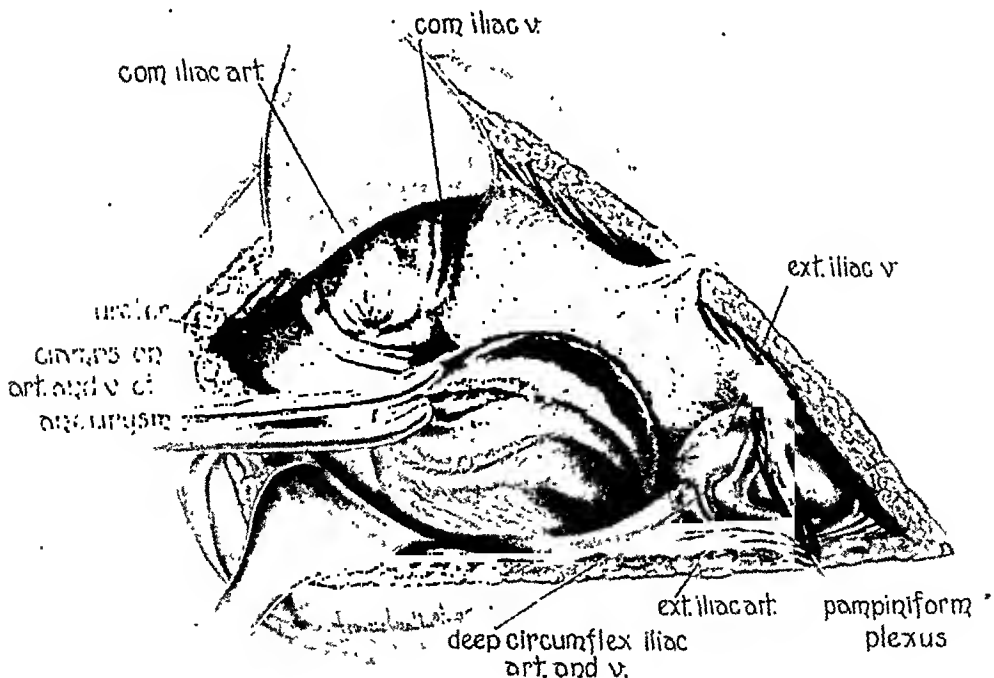


FIG. 2.—Four cardinal points have been ligated and aneurysm has been removed. posterior surface, deep beneath the artery, the common iliac vein. All the visible tributaries of the external iliac vein, *i.e.*, the femoral, deep circumflex iliac and deep epigastric

veins were very much dilated. The admixture of arterial and venous blood could readily be seen through the thin walls of the venous channels. The medial edge of the common iliac vein could just be observed along the corresponding margin of the right common iliac artery. Normally the vein at this level is covered completely by the artery. The main, dilated portion of the vein was also concealed by the common iliac artery, creating the false impression that the diameter of the common iliac vein was much smaller than that of the external. However, on further dissection this was found not to be the case. Distal to the fistulous opening the external iliac artery was of normal size, or perhaps even smaller. On the posterior lateral surface of the artery, lying on the iliacus muscle, was an oval, hard mass, like a hollow chamber, which was connected with the artery and also the vein. One could feel a continuous thrill through its wall. The surrounding adhesions to the artery and the posterior position of the vein and fistula together with the calcification of the aneurysmal sac made separation of the individual vessels and an attempt to close the fistulous opening impractical and because of the size of the vessels, very dangerous. The common iliac artery and vein therefore were separated by blunt dissection and a control ligature placed about the former. The same procedure was carried out on the external iliac artery and vein. The ureter and overlying pampiniform plexus were removed from the surface of the vessels, which were then exposed throughout their continuity. Permanent ligatures of oiled braided silk were placed at the four cardinal points; *i.e.*, below the fistula, around the external iliac vein distal to the entrance of the deep epigastric and circumflex iliac veins; about the external iliac artery proximal to the departure of the deep circumflex iliac and epigastric arteries; above the fistula about the dilated common iliac vein and artery; and about the internal iliac vein (Fig. 1). The control ligatures were removed and after pulling the permanent ligatures home the aneurysm was excised (Fig. 2). Some difficulty was experienced in controlling the bleeding from dilated collateral vessels on the posterior surface of the aneurysmal sac as these vessels were very short, thin-walled and were held patent by the iliacus fascia.

The size of the vessels in the immediate vicinity of the aneurysm would seem to be worthy of record. The right common iliac artery proximal to the fistula was about the size of a normal aorta (Fig. 2). The left common iliac artery was perfectly normal in diameter. The portion of the external iliac artery proximal to the fistula was dilated to the same size as the common iliac and there was some increase, but by no means so great, in the diameter of the internal iliac. The external iliac artery distal to the fistula was of normal size. The deep epigastric and circumflex iliac arteries appeared to be larger than normal. When the permanent ligature about the external iliac artery was pulled home the femoral artery immediately collapsed, but after 15 minutes had passed it again became distended with blood flowing into it by way of the now obviously dilated deep circumflex iliac and epigastric arteries. In other words, in this short space of time the flow of blood in these arteries had completely reversed itself and was flowing from their capillary beds in the opposite direction into the deep circumflex and epigastric vessels, into the distal portion of the external iliac, and into the femoral arteries. This observation was confirmed by a needle prick of the femoral artery which bled readily but not so vigorously as it normally would. The explanation for the selection by the blood flow of the capillaries associated with the deep epigastric and circumflex iliac arteries, instead of proceeding as it does ordinarily into their accompanying venous channels, lies probably in pressure differences. The pressure immediately after ligation of the external iliac artery was zero in the arterial tree distal to the ligature. In the veins, however, the pressure was higher because the deep epigastric and circumflex iliac veins were tributaries of the portion of the external iliac vein forming a part of the aneurysm between the permanent ligatures. Therefore the patency of the veins and the intravenous pressure were maintained by the blood trapped in the ligated venous side of the aneurysm. The maintenance of the venous pressure forced the blood to the lower area of pressure in the artery and very soon re-established the arterial circulation. An explanation is thus afforded for the beneficial

effects of ligation of the accompanying vein when ligating the artery. Numerous experimental and clinical observations have been accumulated to prove the wisdom of this procedure but heretofore the explanation of the *modus operandi* of this beneficial venous stasis has not been set forth. The incision was closed according to the usual manner

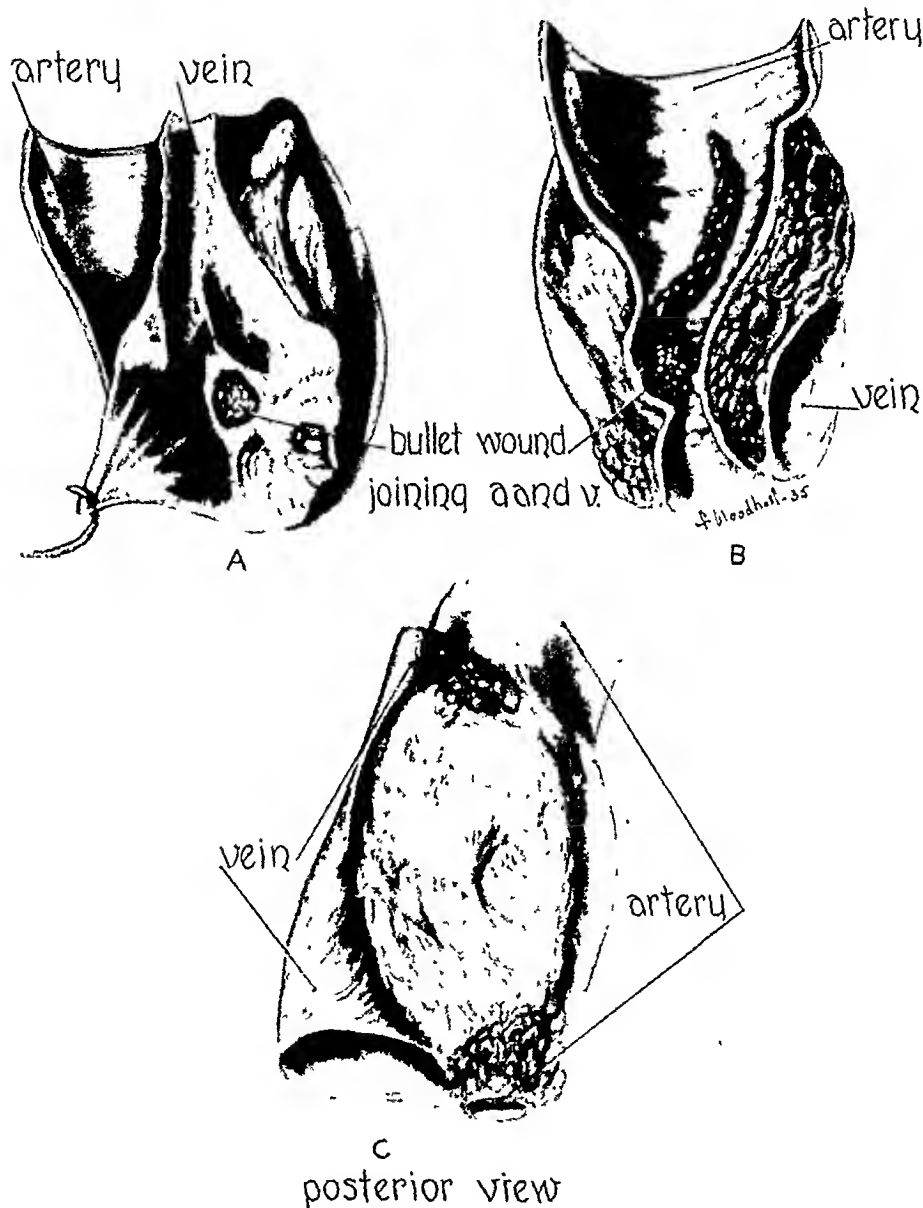


FIG. 3.—Drawings of specimen. (A) Venous side of arterial venous aneurysm showing vegetation in the opening between the external iliac vein and aneurysmal sac. The upper or proximal portion of the vein has been cut across on the bias so as to give the false impression that the lumen of the vein is narrowed in this drawing. (B) Arterial side of specimen revealing the openings into aneurysmal cavity filled with vegetations and the protruding thrombus which points cephalward. Dilated proximal portion of artery shows in upper portion of illustration. The external iliac artery of normal size is shown below. Along the right margin of the artery is the dark calcified wall of the aneurysm. The external iliac vein is on the opposite side lying directly behind the artery. (C) Posterior view of the encysted varicose aneurysm.

without drainage, *i.e.*, the posterior and anterior peritoneum were closed with a continuous suture of fine silk; the anterior sheath of the rectus muscle and skin with interrupted fine silk sutures. The operation required five and one-half hours but the patient, having lost very little blood, was not in the least shocked.

Pathologic Examination: Gross.—The specimen removed at operation measured 8.5 cm. in length and consisted of a portion of the external iliac artery and vein, a portion of the common iliac vein, and surrounding connective tissue and fat. Attached firmly to the posterior lateral surface was an oval calcified mass measuring $6 \times 3.5 \times 2.5$ cm. The vessels were opened along their anterior surfaces and it was then seen that there was a communicating channel between them and the aneurysmal sac situated about 2.5 cm. from the lower end of the specimen (Fig. 3). The opening in the artery and in the vein was one centimeter in diameter. These openings communicated with the calcified, oval chamber so that the blood passed from the artery into the aneurysmal sac and then into the vein. This type of abnormal arteriovenous communication should be termed an encysted arteriovenous aneurysm. In addition to the above described apertures in the vessel walls there was an additional opening between the artery and vein about six centimeters in length which was in reality almost continuous with the smaller opening. Protruding from the cavity of the aneurysmal sac was a thrombus attached to the arterial wall which pointed

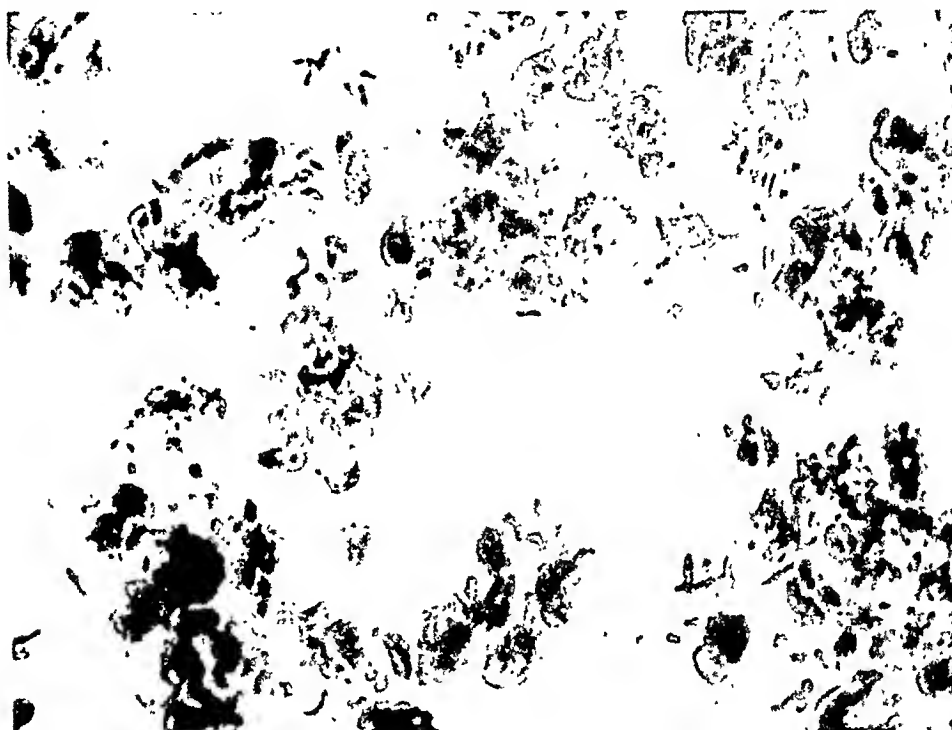


FIG. 4.—Photomicrograph of a section of the vegetations partially occluding the opening between the artery and aneurysmal sac stained to demonstrate bacteria. Many chains of streptococci are present.

cephalward in the artery, probably as a result of eddying currents above the point of the fistulous opening where the artery was constricted (Fig. 3). The walls of the vessels were markedly thickened about the opening. The lumen of the openings into the aneurysmal sac were almost completely occluded by an uneven mass of friable, yellowish-gray material, in appearance quite like the vegetations of bacterial endocarditis.

Microscopic Pathology.—The wall of the artery and vein showed much chronic inflammatory tissue between them. A large channel lined with endothelium connected the two. This channel was filled with an irregular mass of thrombus which at one point showed some organization, but, for the most part, was fairly fresh. It was attached to the wall of the channel on both sides. Scattered through this thrombus were a great many polymorphonuclear cells and groups of large, rather poorly preserved, mononuclear cells filled with great swarms of gram-positive cocci in short chains and surrounded by them (Fig. 4). No bacteria were seen in the tissue.

Postoperative Course.—After the wound had been dressed it was apparent that the circulation in the right leg was defective, as the skin was cold and mottled by areas of

cyanosis. During the operation the leg had been elevated above the level of the heart. The patient was adjusted in the recovery bed so that the leg was held level with the heart and was surrounded with hot water bottles. At the end of an hour the circulation had improved greatly and the temperature of the skin had risen to a point a little above normal. The color of the skin was then a bright pink and the areas of cyanosis had disappeared. It is interesting to note what a profound effect even slight changes in hydrostatic pressure may have upon the circulation of an extremity when the circulation is impaired.

When the patient reached the ward the temperature was 96°, the pulse 160, respirations 48, blood pressure systolic 98, diastolic 74. During the afternoon the pulse rate fell to 130. The following day the patient was much better. The pulse rate varied from 120 to 140. The blood pressure had risen to systolic 128, diastolic 86. The color of the skin had changed gradually from a vivid pink to normal. For a few days there was a little edema of the right ankle but this disappeared as the flushing of the skin subsided. It is possible that cutting the sympathetic nerve fibers about the wall of the external iliac artery

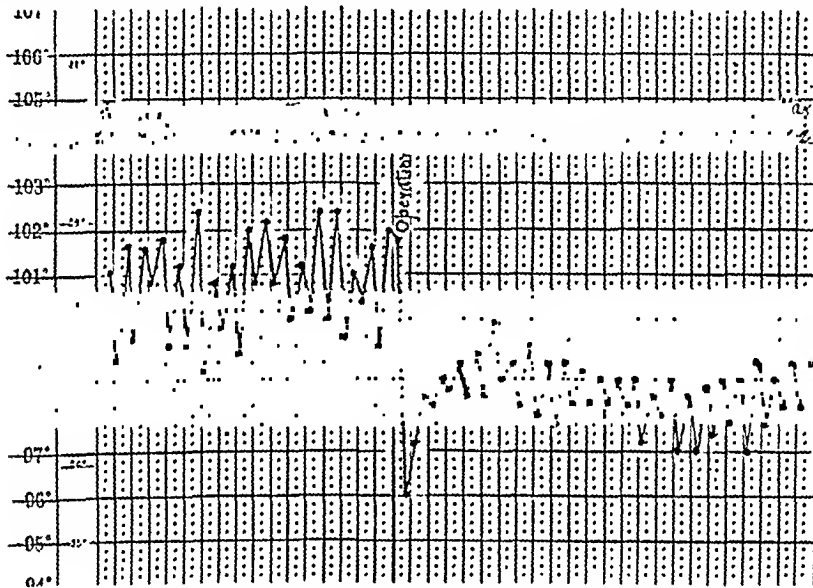


FIG. 5.—Condensed temperature chart, showing the maximum and minimum temperature each day before and after operation. The temperature, varying from 99° to 102.4°, fell to subnormal on the day of operation and after a slight post-operative rise settled permanently to the normal level.

may have caused temporary dilatation of the arterioles in the right leg and in this way accounted for the bright pink color of the skin and the edema. We may assume that as vascular tone returned the color of the skin became normal and the edema disappeared. The variation of the temperature of the skin coincided with changes in color; when the skin was bright pink the temperature was elevated, as the skin assumed a normal appearance the temperature returned to normal. Although the circulation in the right leg was quite adequate to nourish the leg satisfactorily still no pulsation could be felt in any of the arteries and the blood pressure could not be determined.

From then on the patient's recovery was uneventful. The temperature, as shown in the chart, fell to subnormal following the operation and thereafter was never raised but a little above normal (Fig. 5). The patient left the hospital in good condition on March 9, 1935. He had gained in weight. The blood count was at that time practically normal, namely, hemoglobin 85 per cent; red blood cells 4,400,000; leukocytes 6,600. The blood pressure in the arm was systolic 130, diastolic 95. The edge of the liver could still be felt at the costal margin on deep inspiration but the spleen was no longer palpable. Blood cultures were taken two hours after the operation, again during the evening of the same day and on each of the succeeding six days. All of these cultures remained sterile.

Follow Up.—A letter from Doctor Caravati dated April 24, 1935, described the patient's condition as follows: "I am pleased to report that Mr. W. has steadily improved. He is walking about without help and gaining weight steadily. There remains a slight edema of the right foot. He has been constantly afebrile. His pulse now ranges from 75 to 85. No pulsation has returned in the right leg. The liver and spleen are no longer palpable. His blood count is now practically normal. Two blood cultures have remained negative."

On May 31, 1935, the patient came to Baltimore for a final examination. He had gained 40 pounds in weight, had an excellent color and was a picture of robust health. He had been working steadily for a month, at first for half a day but during the previous week for seven hours. He walked about without any support and complained only of a little pain in the leg if he walked too far. At the end of the day there was a little swelling about the ankle which disappeared during the night. The pulse was 76. The right leg was normal in appearance. The right thigh and calf measured one centimeter more than the left. No pulsation could be felt in the right femoral artery nor in any other arteries of the leg.

CONCLUSIONS

We believe that this patient has been cured of *Streptococcus viridans* septicemia by surgical removal of the focus of infection. Certain interesting circulatory phenomena have been observed and described.

THE TREATMENT OF CAROTID CAVERNOUS ARTERIOVENOUS ANEURYSMS

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THIS report is based upon eight cases of carotid cavernous arteriovenous aneurysms treated surgically. Perhaps this condition is better known as pulsating exophthalmos, a term, however, that is less correct because it connotes a symptom rather than the underlying cause; pulsating exophthalmos results from other causes.

Arteriovenous aneurysms of this type are more common than arteriovenous aneurysms in any other part of the body. In fact, I think they occur with greater frequency than all arteriovenous aneurysms combined. There are now reports of over 800 in the literature. When one considers the anatomy of this region, it is not difficult to understand. There are vascular factors that are entirely different from those in any other part of the body. It is, I think, the only location in which an artery actually passes through a venous channel and that accounts, as does also the situation of the lesion, for the high frequency of these aneurysms.

For the production of an arteriovenous fistula in the arm, leg or neck, it is, of course, necessary to have a perforating wound, if the aneurysm is of traumatic origin, which penetrates the walls of both the artery and the contiguous vein. That is not necessary in the case of a carotid cavernous fistula because the arterial wall forms in large part the wall of the venous sinus so that only a tear in the carotid artery, where it traverses the cavernous sinus, is necessary for the production of a fistula.

About three fourths of these fistulae are of traumatic origin, and as so many of the lines of fissure traverse the middle fossa of the skull, it is easy to understand why trauma has such an important bearing on the production of this lesion.

In the other or spontaneous group, the aneurysms, though fundamentally the same anatomically, are due to rupture of latent congenital or acquired aneurysms of the carotid artery or to arteriosclerotic patches in its wall.

Little need be said about the clinical syndrome which is sharply defined and unmistakable. There is (1) exophthalmos, (2) pulsation of the protruding eye, and in the temporal region, (3) a subjective roar which to the observer is a systolic murmur on auscultation.

The treatment of these aneurysms has been most varied. In general it has been along two lines, either from the arterial side, or from the venous side. I have had no experience with the venous side, although good results have been reported.

On the arterial side, the favorite treatment has been total occlusion of either the common or internal carotid artery on the side of the lesion. How-

ARTERIOVENOUS ANEURYSMS

ever, just as good results have now been obtained by partial ligation of either of these vessels. In fact, when one analyzes the after-effects of either partial or total ligations, the results are found to be most capricious. The aneurysms may be cured very easily, or there may be no benefit whatever. In five of our cases a cure resulted soon after ligation of the internal carotid artery (one partial and four total occlusions). In three cases there was no improvement, but in one of these a spontaneous cure resulted five years later—too late for preservation of vision.

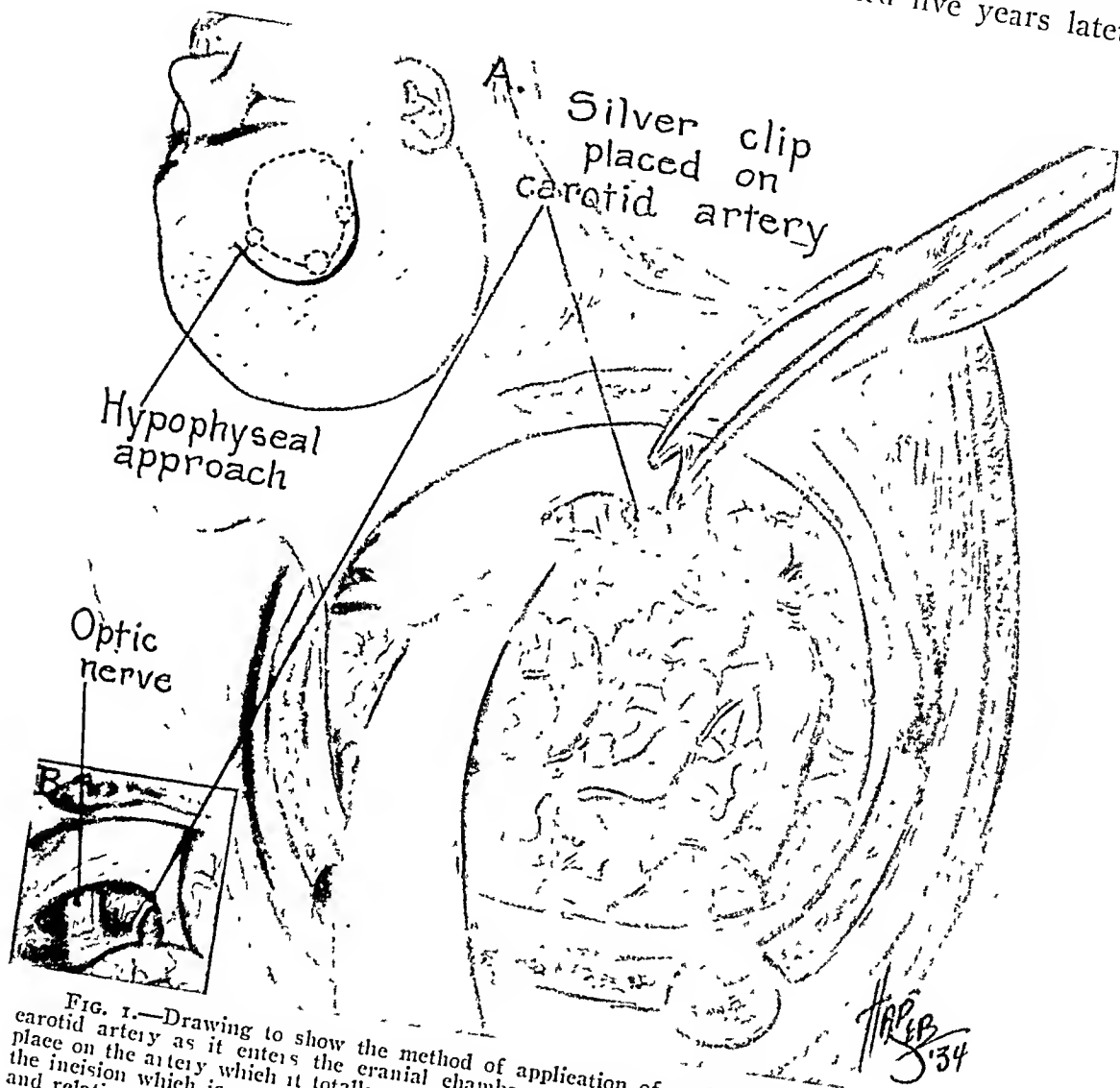


FIG. 1.—Drawing to show the method of application of a silver clip to the internal carotid artery as it enters the cranial chamber. Lower inset shows the closed clip in place on the artery which it totally occludes. Upper inset—The heavy curved line shows the incision which is entirely behind the hair line. The dotted line indicates the position and relative size of the bone flap.

When one analyzes the results, it is quite clear that neither the cures nor failures are dependent upon isolation of the aneurysm by occlusion of the carotid, but upon the development of a thrombus in some part of the vascular apparatus, *i.e.*, in the fistula itself, the carotid artery or venous tributaries which, of course, are principally those of the ophthalmic vein. When the internal carotid is tied in the neck there is always immediate improvement including cessation of the roar, but in 24 hours or less all signs and symptoms have usually returned, though in modified degree, later gradu-

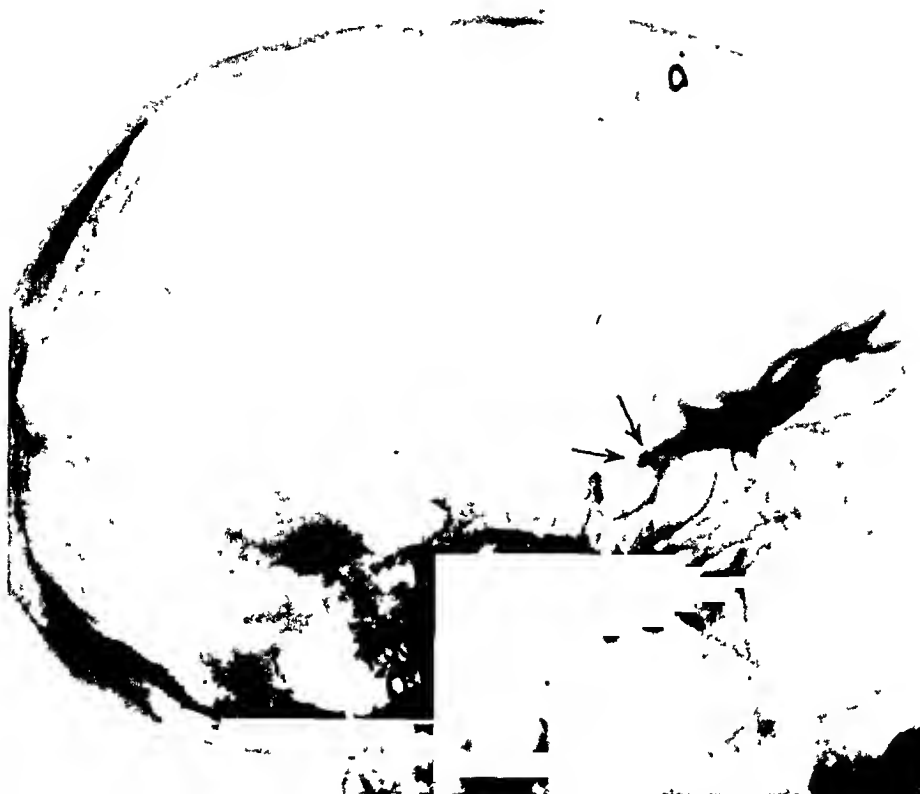


FIG 2.—Roentgenogram showing the clip that has been placed on the internal carotid artery intracranially.



FIG 3—(A) Patient with unilateral carotid cavernous aneurysm, before operation (B) Same patient two weeks after the internal carotid artery has been "clipped" intracranially. This vessel had been previously ligated in the neck

ally increasing. Whether or not there is some permanent improvement or no change depends upon whether or not thrombosis begins during the period of reduced intracranial pressure.



FIG. 4.—(A and B) Two preoperative views of a patient with a right carotid cavernous aneurysm that arose spontaneously.



FIG. 5.—Same patient three months after operation in which the internal carotid artery was closed intracranially by a silver clip. The photograph on the left shows the scar of both the cervical and intracranial ligations, between which the aneurysm was "trapped."

I am mainly concerned with the treatment of those patients who have not been cured by the arterial ligations, whether partial or total. The procedure

that I wish to present is the placement of a silver clip upon the intracranial portion of the internal carotid artery just before it divides (Figs. 1 and 2). It has been employed in two cases (Figs. 3, 4, and 5). The object of this attack is to isolate the aneurysm. This is not strictly correct because there is one sizable branch, namely, the ophthalmic artery between the point of the earlier ligation in the neck and the one intracranially. In one case this branch has had no effect upon maintaining the fistula which was cured immediately. In the other case it was almost a complete cure with complete return of the eyeball to normal, but a slight murmur persisted. It was necessary to excise most of the collateral branches entering the ophthalmic artery (*i.e.*, the branches of the external carotid artery) to complete the cure. In desperation these cases have not infrequently been treated by ligation of the internal or common carotid arteries bilaterally and with a very high incidence of disastrous results.

The exact treatment which one should use depends, of course, upon whether or not the carotid artery can be sacrificed without cerebral disturbances. The physiologic test—compression of this artery with the thumb—should always be made beforehand in order to determine the exact type of ligation to be used. This test has long been emphasized as a necessary prerequisite by Doctor Matas. Roughly the age of the individual is a fairly reliable guide in determining the safety or danger of total ligation, but there are too many exceptions to permit ligation without the compression test. In an elderly person one could only partially ligate the internal or common carotid artery. When partial occlusion is advisable, I prefer the internal carotid and with a band of fascia. To reduce its size one half is safe in elderly persons, and in one of our bilateral cases this was immediately and completely effective. Total arterial occlusion is permissible only when the collateral circulation is known to be adequate. Intracranial ligation of the internal carotid artery is advocated only when all the other arterial ligations have failed to cure.

DISCUSSION.—DR. RUDOLPH MATAS (New Orleans, La.).—Doctor Dandy has given us another striking illustration of the originality, skill and boldness with which he has successfully attacked many of the difficult problems in brain surgery. In this instance he has added another technical achievement to the long list of innovations and advances that are so characteristic of his surgical enterprise. His successful intracranial occlusion of the internal carotid for the relief of pulsating exophthalmos is unique and probably the most aggressive performance thus far recorded for the cure of this dangerous and elusive vascular lesion.

Doctor Dandy's procedure, as I understand it, is to occlude the internal carotid with a metallic (silver) clip, at its exit from the cavernous sinus just below its division into its cerebral and posterior communicating branches. The purpose of the operation is to obliterate the abnormal communication or fistula existing between the internal carotid and the cavernous sinus by arresting the arterial flow on the distal side of the fistula, on the principle of a Brasdor ligation. This would cause a stasis which would favor the development of an obstructive thrombus in the fistula or secondary ob-

structive changes in the artery itself. It is presumed that by occluding the artery intracranially on the distal side, but close to the fistula, the chances of obliteration would be greater than by ligating the artery extracranially, on the proximal side, but at a distance, in the neck.

There are two places in which, theoretically at least, a clip may be applied to the internal carotid within the cranium. The first, in its free portion after its exit from the cavernous sinus, is relatively simple; the second, at its entrance into the cavernous sinus after leaving the carotid canal, where it lies hidden under its dural cover in the parasellar groove. This is anatomically feasible but surgically prohibitive. A clip applied to the carotid in its free portion, after its exit from the cavernous sinus and after it has given origin to the ophthalmic artery, misses the arteriovenous fistula altogether, as this lies in the sinus below the clip. The only real advantage of the clip on the carotid at this level is that it blocks an immediate downward (reversed) flow from the circle of Willis into the fistula. On the other hand, it does not prevent a free flow from the internal carotid into the fistula, as it enters the proximal or cardiac side of the sinus. According to all experience, a clip applied to the carotid on the proximal side of the fistula as this enters the cavernous sinus in the parasellar groove would be more effective than a distal occlusion, just as a proximal ligation on the Anel principle is far more effective for the cure of aneurysm than a distal Brasdor ligation. A mere glance at the anatomic relations of the internal carotid as it lies in the parasellar groove will suffice to show how hazardous such a procedure would be, even though we imagined it to be feasible *in vivo* with the brain *in situ*. To expose the artery in the middle fossa as it lies in the parasellar groove would necessitate an incision through its dural cover and the opening of the cavernous sinus. Apart from the profuse arteriovenous hemorrhage that would follow, the sixth nerve which closely hugs the artery here would be unavoidably injured, with scarcely less narrow escape of the other cranial nerves from the third to the sixth, if the clip were placed on the artery in the cavernous sinus anywhere near the middle or anterior clinoid processes. This, however, is an idle conjecture since it is evident that Doctor Dandy contemplated no such enterprise. He confines his intervention to the distal occlusion of the artery in its free portion at its exit from the cavernous sinus. In order to do this, he opens the skull by way of his well known frontal approach to the hypophysis through a trap-door osteoplastic and dural flap. The anterior lobe is then lifted and the artery is exposed and clamped as it emerges from the sinus between the optic nerve and the motor oculi communis. To do this, as he has done twice successfully, is a fine surgical feat; but it involves, none the less, a severe cranial and endocranial trauma, and adds the dangers that are common to all intracranial operations, without in the least avoiding the risks of cerebral ischemia that are inherent to all the ligations of the common and internal carotid tracts.^{1*} This technic may be simple and its risks perhaps negligible in the hands of such a consummate master of brain surgery as Doctor Dandy, but even so it is a question whether the benefits or possible advantages of such a procedure compensate for the risks involved in its performance. Doctor Dandy, however, frankly admits that his operation is not to be resorted to as a primary procedure, or as a method of election, and only after carotid ligations or other less dangerous and less delicate extracranial methods have failed. But, apart from the

* This and following reference numbers refer to supplementary notes at the end of this discussion.

purely technical aspects of the operation, may we ask, does the intracranial occlusion of the internal carotid, on the distal side of the fistula, offer a greater certainty of cure and protection from relapse that would make it preferable to the methods that are still available when the classic carotid ligations in the neck have failed and relapse has occurred?²

In considering the question of relapse, we should remember that the free anastomoses that exist between the internal and external carotid systems through the circle of Willis on the one hand, and, on the other, through the orbital branches of the ophthalmic artery with the ophthalmic on the opposite side, and with orbital, facial, temporal and meningeal branches of the external carotid, it is always possible for the arterial current to feed the fistula as long as this is not absolutely closed.

Since it is not practicable or even justifiable to attempt the direct occlusion of the fistula by attacking it in the orbit or in the sinus, *i.e.*, *in loco lesionis*, except in advanced cases in which the visual function is lost or permanently impaired, and the saving of the eye becomes a minor consideration—practically all the methods of cure now in vogue aim at the thrombotic occlusion of the fistula indirectly by suppressing or reducing the arterial (carotid) supply to the fistula, or favoring thrombosis by sclerogenic injections on the venous side.

If the thrombotic plug is effective and it organizes into a scar, the fistula is obliterated and the cure, as a rule, is complete, in so far as the gross objective effects of the fistula are concerned. This happens probably in from 40 to 50 per cent of the cases reported as “cured” by carotid ligations alone or combined with other methods of treatment which tend to favor thrombosis in the sinus or in the ophthalmic veins, and indirectly in the fistula itself.³

In a large proportion of cases reported as “improved” (from 40 to 50 per cent), the thrombotic occlusion is only partial, and the relief will depend largely upon the extent of the occlusion. In the great majority, symptomatic relief will be experienced after a carotid ligation; the exophthalmos will recede, vision will be improved, pulsation will cease perceptibly, and the exasperating endocranial bruits will become so subdued as to be quite tolerable. In these cases the relief may be progressive and permanent, and a symptomatic cure will be effected. Judging by my own experience and by a careful scanning of a great number of the reported cures in the literature, I find that in cases in which the exophthalmos, with large pulsating orbital and peri-orbital veins, has figured prominently, the “cure” is only relative and not absolute, as a complete *restitutio ab integro* very exceptionally occurs.⁴

In a considerable number of these reported cases (20 to 30 per cent), after a temporary improvement, which may last from a few hours to two or three years, relapse occurs, varying in time with the persistence of the fistula and the development of the collateral circulation. The exophthalmos then returns with all its aggravating subjective and objective features, visual defects, disturbances and frequent extension to the other eye. The patient is then driven to desperation and the surgeon compelled to adopt more drastic treatments.

Since the new procedure advocated by Doctor Dandy does not aim at a direct obliteration of the fistula, and only indirectly by temporarily reducing or suppressing the carotid circulation on its distal side, it enters into the class of indirect cures by carotid ligation, and it can give no positive assurance of cure, no more than the proximal carotid ligation in the neck. While recognizing that the chances of cure by clotting the fistula may be improved by this procedure in cases in which the carotids have been previously

ligated—because the fistula is then caught between a proximal and distal obstacle put in the course of its arterial supply—it does not follow that such must be the result of the intervention. We should remember that in the relapsed or rebellious cases for which Doctor Dandy has devised his operation the collateral circulation by anastomotic routes between the external and internal carotid systems has had time to develop and become freely reestablished through the fistula. It would seem that, under these conditions, the arterial supply of the fistula will not be so materially checked, even though the reflux coming from the distal side through the circle of Willis has been cut off.

In view, therefore, of what has been said, I would conclude that the intracranial occlusion of the internal carotid on the distal side of the fistula can offer no better chances of cure as a primary or initial procedure than by the extracranial carotid ligations in the neck, in which I believe Doctor Dandy agrees. It is only when the proximal carotid supply has been cut off by a previous ligation in the neck that the intracranial operation has a better chance of proving effectual. That is, provided the collateral circulation coming from the circle of Willis through the opposite ophthalmic artery and the intra-orbital anastomosis of the external carotid has not developed sufficiently to nullify or counterbalance its obliterative thrombogenic effect.

The two recent operations successfully performed by Doctor Dandy redound greatly to his credit and are perhaps the strongest argument in favor of his method, but, much as I admire his originality, his great skill and the boldness of his enterprise, I regret to say that the problem of pulsating exophthalmos has not yet been definitely solved by his experience.

The evidence of Doctor Dandy's success, furnished by his two recent operations, is sufficient to demonstrate the surgical feasibility of his procedure, but not sufficient to prove that it offers greater certainty of cure or protection against relapse, than the less brilliant but safer and more direct methods of treatment that are still available, with as much claim to success, in the same class of cases.

SUPPLEMENTARY NOTES

(1) In my personal experience with 80 ligations or band occlusions of the common and internal carotids we have had nine cases, or 11.2 per cent, in which grave cerebral complications have occurred, and of these six, or 7.5 per cent, died. Three others were saved by the timely removal of the aluminum bands which I use for this purpose. The most striking of these rescues from cerebral death was in an exophthalmos patient who, after he had been saved by the prompt removal of the band, was able to undergo a second occlusion two years after the first attempt, without any notable ill effects, after a four weeks' course of systematic and methodical compression of the common carotid in the neck. The patient was symptomatically cured, and reported himself "entirely well" three years after the operation; but a photograph enclosed in his letter showed that the proptosis still lingered sufficiently to give a slight but distinctive feature to his face. (Matas, J.A.M.A., October 24, 1914).

(2) The problem of pulsating exophthalmos has been attacked surgically in at least five different directions:

(a) On the arterial side by the carotid route. *Extracranially*, in at least nine different ways, including digital and mechanical compression; partial occlusion; ligation of the common and internal carotids and their branches, singly or in different combinations; by the consecutive ligation of both common carotids in relapsed cases; *Intracranially*, by occlusion of the internal carotid (Dandy's operation).

(b) On the arterial side, by plugging the fistula itself, with muscle tissue, by way of the internal carotid (Brooks); by plugging the fistula with paraffin injected into the internal carotid at its origin in the neck (Dawhorn-Matas).

(c) On the venous side: (1) by extirpation of the ophthalmic veins through the orbit; (2) electrocoagulation of the veins by diathermy (Fiolator) extending as far as the sinus; (3) by injecting the veins with sclerogenic solutions.

(d) By direct attack on the fistula at the apex of the orbit, with evacuation of the orbital contents, in cases in which vision is lost and the enucleation of the eye is of minor importance.

(e) By constitutional treatment to increase coagulability of the blood by diet, gelatin injections and other means.

All these methods, whether singly or in combination, claim a share of the successful statistics, except those in Group 2, which are thus far purely theoretical and experimental. Thus far, the arterial attack by compression, and the extracranial ligation of the carotids, retains the supremacy that it has held since Travers, 130 years ago. The venous route, by way of sclerogenic injections, has not been sufficiently exploited in the modern sense. The direct attack on the fistula at the apex of the orbit, with or without evacuation of orbits, remains a supreme resource in old relapsed and inveterate cases in which vision has been lost. Accidental, or spontaneous acute thrombophlebitis, as an intercurrent complication, has proved, in the author's experience, the most effective, complete and radical cure of exophthalmos in the relapsed (ligated) cases.

(3) According to Locke, in his thorough analysis of 588 reported cases of pulsating exophthalmos during the period 1809-1923 (ANNALS OF SURGERY, vol. 80, July, 1924), 272 ligations of the common and internal carotids yielded 187 (68.75 per cent) "cured" or "improved" by these ligations. These ligations do not include 21 bilateral consecutive carotid ligations in relapsed cases, with 61.91 per cent cures, nor 24 primary carotid ligations combined with orbital vein ligations, with 37.50 cures, and 33.33 per cent improvements.

(4) The term "cure" simply means that the abnormal arteriovenous flow through the fistula has been checked, but the effects of the arteriovenous lesion on the contents of the orbit, the eye, and the veins of the orbit, persist in long standing and especially bilateral cases, as tell-tale relics of the previous existence of the exophthalmic disorder. I dare say that in the majority of the reported "cures" faint murmurs will be heard with the stethoscope and by the patient himself, if he listens intently with his head on a pillow in the stillness of the night. Travers' now historic case of first carotid ligation for exophthalmos still showed signs of the old disfiguring disorder, which could not escape detection by even an inexperienced eye, seven years after an apparent symptomatic cure had been accomplished by the ligation. In this connection I would say that the most complete and radical cures that I have known are those which have followed the obliterating effect of an acute, spontaneous thrombophlebitis. We have had four such cases, in three after failure of carotid ligations. It is this experience that has convinced me of the neglected advantage of attacking a rebellious exophthalmos by combining the carotid ligation with mild obliterating sclerogenic injections (*e.g.*, 50 per cent dextrose or crystallose) into the ophthalmic veins, and in this way inducing a relatively benign thrombophlebitis in imitation of Nature's mode of cure.

DR. HOWARD C. NAFFZIGER (San Francisco, Cal.).—I understand from Doctor Dandy that the clipping of the carotid is, of course, distal to the origin of the ophthalmic artery, and I understand that there has been no subsequent difficulty with vision. I should think that visual disturbances would be common following the ligation of the carotid artery in this location and that collateral circulation would be inadequate, and have been fearful of an intracranial tie for that reason.

We have had about 15 of these patients. Doctor Locke reported a number some years ago. Our experience has been the same as that of others, namely, that the most satisfactory results are found in those patients who have spontaneous healing. We followed the progress of one patient, who had no treatment, for 10 or 15 years. His bruit remained the same and there was no change in his eye. A comparison of his progress with that of patients who had had the internal carotid tied showed very little difference.

We have banded and tied the common carotid, but more frequently the internal carotid.

In the treatment of these patients we have noted that the frequent digital compression of the common carotid artery is helpful. This, however, is a tiresome procedure and cannot always be continued for as long a period as is desirable. One of our patients used a trouser clip—the kind used to hold the trousers away from the chain of a bicycle—which has proved to be a most effective piece of apparatus.

The pathologic change in this condition is, in my opinion, a relatively slow process rather than a tear. I think that there is a latent period of from two to three weeks in which the bruised wall of the artery becomes progressively weaker and finally ruptures. In the literature, as I recall, the average time of the appearance of symptoms after injury is given as about 21 days. In our cases the symptoms usually have appeared between two and three weeks after injury.

In connection with Doctor Dandy's procedure, I should like to ask particularly about the circulation in the ophthalmic artery, as that would be a cause for worry.

DR. MONT R. REID (Cincinnati, Ohio).—I think Doctor Dandy has made his point perfectly clear that he would not resort to this method until all other procedures had failed. One or two things might be stressed regarding the procedures which should be tried before resorting to intracranial manipulations.

It is extremely important to pay attention to the possible collateral circulation through the external carotid artery. If one should elect to ligate the common carotid artery alone there will be a reversal of the flow of blood in the external carotid back into the internal carotid and thence on to the brain. Consequently, if one ligates the common carotid artery the external carotid should also be ligated, in order to reduce to the maximum amount the arterial circulation through the fistula. It may also be true that if one ligates the internal carotid one can further reduce the arterial circulation through the fistula by ligating the external carotid which anastomoses with branches of the ophthalmic artery. My practice has been to occlude the common carotid artery with a metallic band, which can be removed later if necessary, and at the same time to ligate the external carotid.

I think it is advisable to attack the venous side if the arterial ligations in the neck fail to cure the fistula. As deSchweinitz pointed out a good many years ago, many of these cases have been cured by simple ligation of the supra-orbital vein and this might be done after the arterial ligations. It seems to me we may do more than ligate the vein. It might be possible to open it and to introduce some sclerosing solution back toward the cavernous sinus and thus promote thrombosis. In one of our cases we have opened the supra-orbital vein and tried to introduce into it a little flexible probe, something like a miniature test tube cleaner, after dipping it into 50 per cent glucose solution. I simply bring out those points as possibly worth trying before resorting to the intracranial approach.

One other point: we believe that the older patients are, the less likelihood there is of cerebral disturbance following ligation of the carotid artery. I do not know the explanation for this, unless the cerebral vessels become more or less rigid later on in life and are not subject to collapse of their walls and to the vasomotor spasms that you get in younger people. Certainly our experience has been that it is safer to ligate the carotid vessels in older people than in young people.

DR. WALTER E. DANDY (Baltimore, Md.).—It has been our thought in this procedure that perhaps the aneurysm might be isolated and the cure might not require thrombosis. There is, of course, one sizeable branch—the ophthalmic artery—between the intracranial and the cervical ligatures.

In answering Doctor Naffziger's query, concerning the danger to vision by so isolating the ophthalmic artery, I can only say that in neither of the two cases was there any postoperative loss. This was indeed our greatest concern, and both patients were warned that blindness of the affected eye might result. As they came out of the anesthetic the pupil on the side of the ligation was widely dilated, but when fully awake toward evening the vision was perfectly normal.

Since the collateral circulation from the branches of the external carotid artery has maintained the circulation to the eye, it may well be that the same circulation will maintain the aneurysm, though at a reduced pace, until thrombosis completes the cure.

The results from deep intra-orbital ligations of the huge ophthalmic vein have been published by deSchweinitz, Sattler and others. Although most of the reports are quite meager, some of the cures are no less perfect than by the arterial ligations. Immediately following ligation of the ophthalmic vein there is always an acute alarming intensification of the exophthalmus and chemosis. This change is due to the strain thrown upon the remaining venous channels in the orbit after the sudden removal of the big venous bed through which the arterial blood has been making its exit.

Then too, I have been fearful of ligating the ophthalmic vessels deeply in the orbit because of the danger of injuring the extra-ocular muscles or their nerves; a non-focusing eye is scarcely better than a blind one. I feel that the safer attack upon carotid cavernous aneurysms is through the arterial ligation, and with proper care in the procedure, *i.e.*, partial or total depending upon a preoperative determination of the collateral, there should be a minimal risk to life or function. I should like to repeat that when intracranial clipping of the carotid artery is necessary there is no risk to the circulation of the brain because the internal carotid has already been ligated in the neck.

INFLUENCE OF URINARY BLADDER TRANSPLANTS ON HYALINE CARTILAGE *

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IN VIEW of the surprising results obtained from studies of the ability of the epithelium of the dog's bladder to stimulate bone formation, it seemed desirable to observe the effect of bladder epithelium on cartilage.

A previous article reported the results of experiments in which defects in the ulnas of dogs were bridged by transplants of the mucous membrane of the urinary bladder of the same animal.^{10, 11} These experiments were based upon an observation of Huggins^{1, 3} who found that, if the mucous membrane of the urinary bladder of dogs was transplanted to the rectus sheath, fascia lata or subcutaneous tissue, a cyst lined by bladder epithelium was produced, and true bone was almost always formed in a part of the wall of the cyst. This is true bone in that it contains haversian canals and hematopoietic marrow, and its formation appears to be due to some influence of the proliferating cells lining the cyst or their products. Osteogenesis also followed transplantation of kidney pelvis, ureter^{2, 5} and gallbladder⁷ into parietal connective tissues of the abdominal wall, extremities and neck but did not occur following similar transplantation of gastric, jejunal and prostatic epithelium. The connective tissue surrounding the epithelium in the urinary tract and the fibroblasts within solid organs such as the kidney cortex, liver and spleen do not react to transplanted bladder mucosa by forming bone. The secretion of fluid in epithelial-lined cysts of the transplanted mucosa was found by Huggins and Compere⁶ to contain relatively large amounts of calcium and phosphorus, as compared with the blood of the same animal, and this fact is considered a factor in the bone formation. Huggins⁴ later found the phosphatase activity to be relatively high in the various stages of heterotopic osteogenesis in transplants of bladder mucosa. He^{8, 9} also studied heterotopic formation of dentine and enamel by transplantation of epithelium and pulp tissue, and found the reaction similar to the production of bone by transplanted urinary tract epithelium. Other literature concerning heteroplastic formation of bone has been reviewed by Huggins.³

Our own experiments¹¹ indicated that the presence of a growing autologous transplant of epithelium from the urinary bladder of a dog stimulated osteogenesis in a defect in the ulna and caused the defect to be bridged by new bone which resulted ordinarily in union. Control defects in the other ulna of the same dog which did not have a transplant failed to unite. Examination of the specimens indicated that the new bone was formed directly under the influence

* Dr. William Ehrlich assisted in performing the experiments.

of the growing transplanted epithelium of the bladder rather than to any influence of the periosteum or of any other structure. Furthermore, the bladder transplant tended to prevent atrophy of the ends of the bone defects which uniformly occurred in the same dog on the control side with nonunion of the ulna. The new bone was usually formed directly in the connective tissue and was not preceded by the formation of cartilage.

We were unable to explain the exact mechanism by which the bladder transplant caused formation of bone. Various kinds of extracts of bladder epithelium of dogs and hogs proved to be inactive in bringing about union of experimental fractures. One extract of bladder epithelium* temporarily raised the blood calcium and lowered the blood phosphorus when given intravenously to dogs. It is possible the new bone resulted in part from a local excess of calcium or of phosphatase which was secreted by the epithelial cells of the transplant.

METHOD.—To investigate the effect of the mucous membrane of the urinary bladder on cartilage, surgical operations were performed aseptically on 12 dogs under ether anesthesia. It was thought desirable to use hyaline cartilage for the experiments since it is the most primitive and most widely distributed type, and is readily available in costal cartilages. The operative procedure follows:

Sections of either the eighth, ninth, tenth or eleventh costal cartilages averaging from 2 to 3 cm. in length were resected subperichondrially on each side of the chest. In some of the animals the perichondrium was poorly developed. The urinary bladder was exposed and a piece of the entire wall of the bladder approximately 3 cm. square was excised. The bladder wound was sutured and the abdominal wall was closed. The mucous membrane was dissected carefully from the muscularis of the piece of the wall that had been excised. The isolated epithelial layer is of tissue paper thinness and texture. The small strips of mucous membrane were transplanted by stretching them across the defect in the costal cartilage and by suturing them in place against the ends of the cartilaginous defect with fine silk sutures. Usually the transplants were made to the right side of the chest only, however, in a few of the animals bilateral transplants were made. The wounds were carefully closed about the transplants with interrupted silk sutures. The control side without a transplant was closed in the same manner. The animals were sacrificed at various intervals from four days to six months after operation and the anterior half of the thorax was removed en masse for roentgenologic, and for gross and microscopic study.

RESULTS.—Gross Appearance.—There was no difference of note in the experiments of short duration between the control side and the defect containing the bladder transplant. In the experiments of longer duration the ends of the cartilage on the control side were united by fibrous tissue. There remained slight depressions at the site from which the cartilages had been

* Made by Eli Lilly.

BLADDER TRANSPLANTS ON CARTILAGE

removed. The defects in the same animal which were bridged by bladder mucosa were usually filled by a mass of tissue consisting of bone and cysts varying in size according to the duration of the experiment. The cysts were both multiple small ones and multilocular. A false joint was always found at the site of the defect on the control side, while on the side of the transplant there tended to be some fixation of the ends of the cartilage by the mass of tissue depending upon the duration of the experiment. There was no palpable evidence of regenerated cartilage in any control specimen. On section across



FIG. 1.—Roentgenogram of anterior portion of dog's chest. On the left side may be seen the experimental control defect in the tenth costal cartilage. The defect in the right tenth costal cartilage is filled with a cystic bony mass that resulted from an autogenous transplant of urinary bladder mucosa. The transplantation was made at the same time the defects in the cartilage were created, eight weeks previously.

the cartilaginous defect there was seen grossly a ribbon of dense but pliable fibrous tissue.

Roentgenologic Examination.—Postmortem roentgenograms of the anterior half of the thoracic wall of each dog were made. On the control side the shadow cast at the site of the defect is of no greater density than the surrounding soft tissue. The ends of the cartilage at the defect are clearly outlined and atrophic changes are little if any. This is in contrast to defects in bone as observed by roentgenograms in other experiments which showed

rarefaction, particularly of the ends of the bones, and a definite decrease in the diameter of the remaining shaft.

In the experiments of short duration with cartilage the roentgenograms of the transplant and the control sides were practically the same. As early as three weeks the defects in the cartilage that had been bridged by bladder transplants are occupied by a mass of calcified tissue several times larger than the original defect (Fig. 1). The calcified mass known to be composed largely of bone contains many clear areas of various sizes. These clear areas represent multiple cysts formed by the proliferating bladder epithelium. In the longer experiments the calcified tissue in the defects cast a denser shadow and the clear areas are not pronounced. Furthermore, some of the ends of the cartilages are rarefied and the size of the defect seems slightly increased. These latter findings give the impression that the calcified mass has replaced small portions of the cartilaginous ends of the defects. This observation has been verified by histologic sections.

Microscopic Examination.—Controls: The defects in the early experiments were filled with a mass of blood clot and granulation tissue, and the ends of the cartilage are sharply demarcated from these tissues. Throughout the length of the older defects there can be seen microscopically dense fibrous tissue (Fig. 2). The ends of the cartilage are rounded and the cartilage usually remains separated from the surrounding perichondrium. Occasionally the ends of the cartilage fuses with the perichondrium and together they join the mass of fibrous tissue filling the defect. Very rarely there may be found in a few sections interspersed in the fibrous tissue small islands of fibrocartilage, doubtless having arisen from small pieces of cartilage left attached to the perichondrium at the time of the subperichondrial resection. There is no evidence of invasion of the defect at either the sternal or costal end of the defect by proliferating cartilage or bone. The rounded ends of the cartilage are little atrophied, are not calcified, and have failed to regenerate.

BLADDER TRANSPLANTS INTO DEFECTS OF COSTAL CARTILAGE

In the seven and fourteen day experiments the defect in the hyaline cartilage is filled with an organizing blood clot containing masses of bladder epithelium in which the cells are proliferating. Many of the masses of cells have formed small cysts which occur as single, multiple and multilocular types (Fig. 3). These early cysts do not contain a material that can be fixed and stained, and they are surrounded by a layer of fine, loosely arranged and probably edematous young connective tissue. The epithelium of the cysts is transitional in type, of a hardy variety, and consists usually of a number of layers. The shapes of the cells vary but most are ovoid. The cells of the superficial layers are larger and are stained less with eosin than the deeper ones that tend to overlap each other. All phases of mitosis can be seen in the nuclei. There is no bone around the walls of the cysts at the end of two weeks. The ends of the cartilage that had been resected to make the defect are apparently viable and show no evidence of regeneration after 14 days.

The ends are rounded and covered with perichondrium which fuses with a mass of connective tissue that fills the defect.

Sections made from the 21-day-old experiment first show that the growing bladder epithelial cells have the remarkable power of producing ossification of



FIG. 2.—Section made through an experimental defect showing the space between the rounded cartilaginous ends to be filled with fibrous tissue.



FIG. 3.—The proliferating cells of the bladder mucosa are seen to occur in masses and in small cysts two weeks after transplantation. A layer of edematous young connective tissue immediately surrounding the proliferating cells separates them from the older connective tissue.

hyaline cartilage. The epithelial cells by this time have increased in number and have become flattened as if the cyst were distended. The walls of the cysts fortunately have grown in many specimens directly in contact with hyaline cartilage and perichondrium, with only a very thin layer of loose

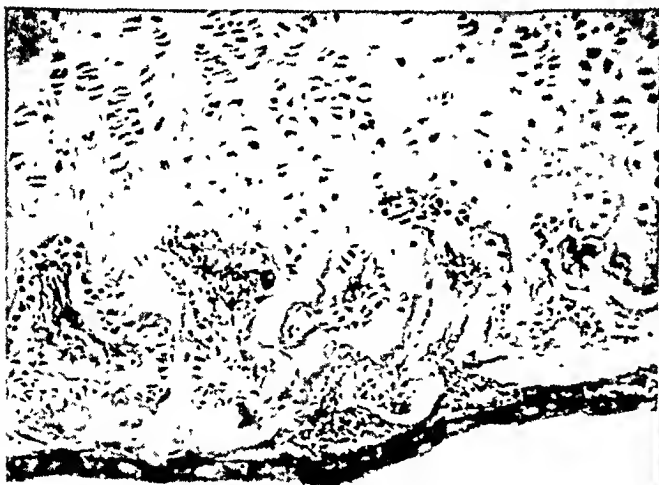


FIG. 4.—Early destructive changes have taken place in the hyaline cartilage where it is in contact with the proliferating bladder cells of a cyst. Osteogenic tissue can be seen invading the matrix and enlarged lacunae.



FIG. 5.—More advanced changes have occurred at the end of eight weeks in the cartilage under the influence of bladder mucosal cells. Spicules of bone are being formed in the region of the mucosa.

young connective tissue and blood vessels intervening. The structure found eventually in contact with the autotransplants and its proliferating cells is a fortuitous matter. Further, it is to be recalled that Huggins¹ found, and we confirmed his findings, that bone usually does not completely surround a

single large cyst and that it is formed always in the vicinity of the newly formed epithelium rather than the original transplant. Therefore, the chance of position plays an important rôle in determining what tissue is brought under the influence of the proliferating bladder cells. It is evident, however, from sections that the effect of growing bladder epithelium is far reaching and that it is not necessary that it be immediately adjacent to cartilage to effect it.

Under the influence of the bladder cells, the hyaline cartilage may be seen being replaced by bone and bone marrow. All phases of this transformation will be described from study of many sections made from specimens obtained from the different experiments. The 21-day-old experiment, as well as the older ones, may have present several stages of replacement of cartilage by bone, and also show the formation of bone from connective tissue and from perichondrium. In all instances the newly formed bone is lamellar bone with haversian systems and contains much bone marrow.

Marked changes in hyaline cartilage takes place early when it is in contact with growing bladder cells that form the wall of the cyst. The epithelium is separated from the cartilage by a thin layer of fibroblasts and blood vessels only (Fig. 4). Among the early changes noted are the proliferation and hypertrophy of the cartilage cells which results in greatly enlarged lacunae that often contain several cells. The enlarged cartilage cells tend to be arranged in rows, more or less parallel to the wall of the cyst and are often separated only by narrow transverse partitions. The matrix adjacent to the bladder epithelium is invaded by newly formed blood vessels and young connective tissue in which osteoblasts and primitive marrow cells are constantly differentiating. The invading osteogenetic tissue opens the enlarged lacunae, breaking the matrix into irregularly shaped septa with marrow spaces between them. The edges of the septa that project from the main body of cartilage and the particles of matrix that have been completely isolated stain more deeply than the other portions of the matrix. This fact indicates the deposition of calcium in the matrix and, as can be seen later, it is in preparation for ossification which takes place rapidly. The cartilage cells near the zones of calcification show signs of disintegration and mainly disappear early.

The osteogenetic tissue between the projections of cartilage that are undergoing calcification becomes progressively more active from month to month (Fig. 5). In addition to young connective tissue and blood vessels, there can be seen in the older specimens, young and mature forms of erythrocytes, granulocytes, lymphocytes and monocytes. Multinucleated cells are numerous and they appear often to take a prominent part in the breaking up of the cartilage. Some of the cells of the osteogenetic tissue adjacent to the cartilage in process of calcification differentiate into osteoblasts which proceed with endochondral ossification. They arrange themselves around the projections or the islands of partially or completely calcified cartilage and form layers of bone, usually enclosing cartilaginous remnants that disappear. The process of calcification proceeds simultaneously with ossification, the zone of calcification shading into a zone of ossification. The spicules of spongy bone increase in

size, particularly in length, as the osteoblasts continue to lay down more bone (Figs. 5, 6 and 7). The fibers and calcified matrix of the bone are deposited



FIG. 6.—The histologic appearance 20 weeks after transplantation of bladder mucosa near cartilage resembles an ossification center in an epiphysis. The replacement of the hyaline cartilage by spongy bone can be clearly seen. Only small portions of the walls of two epithelial cysts show in the lower parts of the photomicrograph.

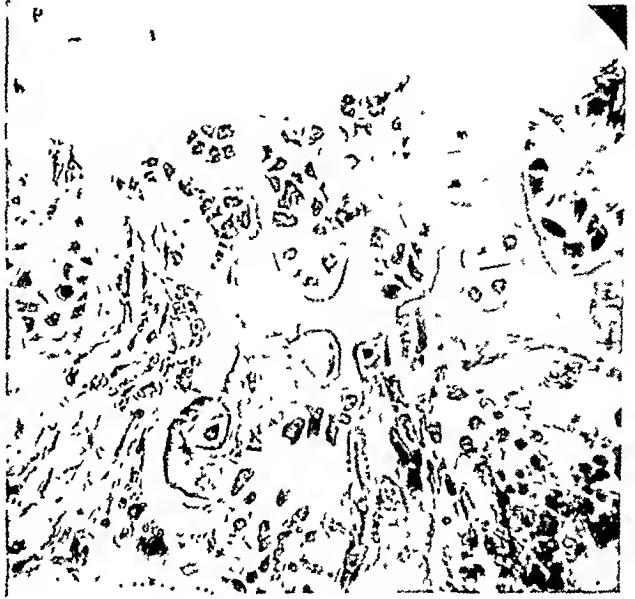


FIG. 7.—A higher magnification of the zone of cartilage in Fig. 6 which is being invaded by osteogenic tissue.

in thin layers or lamellae. The spicules of bone at the end of five months have become quite dense but the type of bone remains spongy rather than compact. The spicules tend to anastomose to form trabecula and to enclose large



FIG. 8.—A higher magnification of a portion of Fig. 6, showing trabeculae of bone surrounded by osteoblasts and mature bone marrow. In the lower portion of the view may be seen two masses of bladder cells.



FIG. 9.—Bone is forming after three weeks in cartilage that is surrounded by an epithelial wall of a cyst. The bone is replacing the cartilage by a more direct method than the one illustrated by preceding photomicrographs. The reticular tissue of the marrow shows well.

amounts of mature marrow (Fig. 8). The bone thus formed is not destroyed by the action of osteoclasts or osteolytic agents and it shows no tendency to atrophy. Osteoclasts are comparatively rarely seen in any of the sections.

The total amount of hyaline cartilage replaced by endochondral bone formation is not large at the end of five months. The process, however, had been progressive and doubtless more cartilage would be replaced if the experiments had been allowed to continue longer.

Some of the sections showing the process of transformation of cartilage to bone that has been described, also shows less commonly a more direct method of replacing cartilage by bone. The two processes may proceed simultaneously in different regions, sometimes about the same cyst of vesical epithelium. Sections made from the 21-day-old experiment show new bone with marrow to have replaced already considerable cartilage by this different method (Fig. 9). The cartilage in the region of the bladder epithelium and at some distance from it has been stained pink with eosin, indicating probably that some calcification of the matrix has taken place. The lacunae are evenly



FIG. 10.—Higher magnification of a bone forming zone of Fig. 9. The collagenous fibers can be seen among the cartilage cells and calcified matrix. A thin layer of osteoid tissue lies between the single epitheloid layer of osteoblasts and the bone. An osteoclast in the lower left portion of the picture has begun to separate a spicule of bone. A very young marrow space is near the center.



FIG. 11.—A small piece of cartilage has been completely replaced by bone and bone marrow at the end of three weeks. The bladder epithelium surrounds the region and in one place occurs as a papillary prolongation. The periosteal layer can be distinctly seen next to the bone, particularly in the upper portion.

distributed up to the area adjacent to the line of ossification. Although here the cells are moderately compressed, the lacunae and their cells retain their identity and appear quite distinct. In this same region the character of the intercellular substance changes so that the collagenous fibers of the cartilage are visible. These fibers and the rest of the matrix become more confluent and stain more deeply. The calcified zone changes almost abruptly into an ossified zone, however, without a strict line of demarcation. Most of the lacunae disappear. A few of the cells are enmeshed apparently in the newly formed bone which is being laid down on the calcified cartilage by a single row of osteoblasts that line the peripheral margin of the bone (Fig. 10).

Several spicules of bone have been made and displaced from the zone of ossification by this method. The spicules are separated as they are ossified presumably by two methods. Osteogenic tissue is found enclosed in small

spaces which increase in size particularly lengthwise, separating the spicules from the zone of ossification as the process is completed. The osteogenic tissue or primitive marrow multiplies and provides among other things osteoblasts for the deposition of new layers of bone on the spicules that have separated. Simultaneously the separation of spicules is aided by the resorption of bone by a few osteoclasts found lying in little depressions which they have hollowed out in the new bone. The peripheral bone spicules that have been separated are partially surrounded by a layer of osteoblasts and are separated from the adjacent bladder cells by a small amount of loose connective tissue. Between the bone spicules are comparatively large spaces filled with bone marrow. In the meshes of the reticular connective tissue are found a profusion of the many different types of marrow cells. This process of bone formation is rapid. At the end of 21 days small areas of cartilage have been



FIG. 12.—Cartilage is being replaced directly by bone. This process at the end of eight weeks is essentially the same as the one found at the end of three weeks and is shown in Figs. 9 and 10.



FIG. 13.—A thin layer of bladder epithelium surrounds the bone which had its inception in perichondrium. The layer of very active osteoblasts can be seen adjacent to a thin layer of osteoid tissue which is beside the bone.

completely replaced by spongy bone and marrow. The spicules tend to anastomose to form trabeculae and are surrounded in part by periosteum (Fig. 11).

This process of bone formation is found in sections made from older experiments. The region of the collagenous fibers between the normal cartilaginous matrix and the bone is wider and is more vascular than is found earlier. The bone is sharply demarcated from this latter region (Fig. 12).

The perichondrium about the cartilage at a distance from the bladder epithelium has little evidence of activity. However, in a region where the epithelium is adjacent to perichondrium and cartilage there is evidence of marked activity. The cells of the cartilage proliferate and the matrix becomes calcified. Osteoblasts are formed from the perichondrium and from osteogenic tissue between the cartilage and the wall of the cyst. These osteoblasts rapidly produce layers of bone which replace the cartilage. Moreover, bone

is readily formed where bladder epithelium and perichondrium only are adjacent to each other (Fig. 13). The cells of the inner layer of the perichondrium multiply rapidly and osteoblasts are formed that promptly manufacture bone. In this region may be seen very well a thin layer of material immediately adjacent to the row of osteoblasts that stains pink rather than red with eosin. As this so called osteoid tissue becomes ossified a few of the osteoblasts are enclosed in the bone and so become osteocytes. As the deposition of bone continues the character of the cells of the inner layer of the perichondrium changes. The nuclei become more numerous, mitosis is common, and the cells do not stain so deeply with eosin. This layer of tissue may now be referred to as periosteum. The outer side of the spicule of bone is very close to the cyst wall, only a thin layer of cells intervening, some of which are osteoblasts. It appears though that the lamella are nearly all laid down on the periosteal side. Small marrow spaces may be seen in the young bone.

Bone may be formed directly from connective tissue under the influence of growing bladder cells, in addition to the different methods of replacing cartilage by bone that have been described. This former process is similar to that which was first noted by Huggins.¹ Sections made from short term experiments show a spicule of bone to have already formed (Fig. 14). It is apparently separating from a sharply demarcated zone of calcified connective tissue derived from abutting connective tissue. The sharpness of the change from uncalcified to calcified connective tissue and to bone without visible agents between the layers of tissue is notable. On the edge of the bone peripheral to the site of ossification is a layer of osteoblasts. These cells also surround the bone near the cyst wall. Small round areas of primitive marrow can be seen in the spicule of bone and in larger areas adjacent to it.

A few of the sections made from older specimens indicates that under the influence of the epithelial cells of the cyst wall, cartilage may be formed from dense connective tissue which in turn is replaced by bone (Fig. 15). In portions of the zone of calcified tissue may be seen lacunae. This region of cartilage is invaded by osteogenic tissue which leaves septae and islands of calcified tissue that are surrounded by osteoblasts and osteogenic tissue. The osteoblasts lay down new bone about the remnants of cartilage and in connective tissue. Ossification proceeds in this manner until bone formation is complete.

RÉSUMÉ AND COMMENTS

Small defects in hyaline cartilage of the dog failed to regenerate in six months after costal chondrectomy even though the perichondrium is not removed. The experimental defects in the cartilage become filled with fibrous tissue. Similar defects in costal cartilage that have been bridged by autogenous transplants of urinary bladder mucosa become filled after a time with a mass consisting of spongy bone, bone marrow, and epithelial cysts. Under the influence of the proliferating cells from the transplanted bladder mucosa,

BLADDER TRANSPLANTS ON CARTILAGE

Fig. 14.—The bladder epithelium can be seen surrounding a spicule of bone that has been formed alongside a layer of densely calcified fibrous tissue.



Fig. 15.—In this specimen the fibrous tissue was changed into cartilage and then into bone by some influence of the bladder epithelium that is seen growing in the lower part of the picture.



the cartilage cells hypertrophy and create greatly enlarged lacunae. The calcified matrix is broken into particles which become ossified by the invasion of newly formed blood vessels and young connective tissue, in which osteoblasts and primitive marrow cells are constantly differentiating. The histologic picture closely resembles endochondral ossification that takes place in the calcification zone of the epiphyseal ends of the growing long bones where hyaline cartilage is replaced with osseous tissue. Bone resorption and replacement, however, do not follow the original bone formation in our experiments, nor does the costal cartilage constantly proliferate to furnish new material for invasion by osteogenic tissue as ordinarily happens at the ossification center of an epiphysis. Simultaneously with the preceding process there may be formed a layer of perichondral bone from the inner layer of the perichondrium. The perichondrium becomes periosteum with the deposit of perichondral bone. None of the sections reveal any evidence that perichondrium has been stimulated to produce cartilage.

The repair of experimental fractures apparently has many features that are analogous to the endochondral ossification that occurs under the stimulus of bladder epithelium. Ham¹² found the usual repair of a fracture in rabbits to be due to osteogenic cells capable of differentiating into either bone or cartilage. The matrix of the cartilage of the callus becomes calcified, the lacunae enlarged and coalesced. This region is invaded by osteogenic cells and the calcified matrix differentiates directly into bone.

A less common but a more direct replacement of cartilage by bone is accomplished under the influence of the proliferating bladder mucosa. Osteoblasts deposit a layer of osteoid tissue, which quickly become bone, upon a zone of heavily calcified matrix. The transformation from cartilage to bone is speedily accomplished without the destructive changes in the cartilage that we have described as simulating the calcification zone of an epiphysial end of a long bone. Apparently the calcified matrix acts as a local deposit of calcium salts for the adjacent osteogenic tissue which has given rise to osteoblasts and marrow. This process is not strictly analogous to direct or intramembranous ossification in that this latter method characteristically is not associated with cartilage but is formed directly from embryonal connective tissue. The replacement of cartilage by bone is direct, however, and as in intramembranous bone formation the bone is formed through the medium of osteoblasts. The osteoblasts, in part at least, seem to deposit their hyaline ground substance upon collagenous fibers of the disintegrating calcified cartilage. The growing bone trabeculae may be surrounded by periosteum and the spaces between the spicules are abundantly filled with marrow. The production of hematopoietic marrow in all of the experiments is as striking as the bone production.

The latter method of production of bone from calcified cartilage is almost identical with the production of bone from calcified dense connective tissue. It is not surprising that in some instances that fibrous tissue should be changed into cartilage in the process of ossification. The change is quickly made and seemingly is accomplished under the influence of bladder epithelium.

The histogenesis of the bone is the same in the different types of ossification found in our experiments in that the bone is actually formed by osteoblasts. Osteoblasts are formed readily from young connective tissue under the influence of bladder epithelium.

The nature of the agent derived from proliferating mucosal cells of a urinary bladder transplant or their products is not known but is presumably a physiochemical one. It has been shown to induce bone formation in certain connective tissues, to stimulate osteogenesis in experimental bone defects, to produce endochondral and a more direct type of ossification, to stimulate bone formation from perichondrium and periosteum, and to give rise to capillaries and large amounts of marrow. By inference the same force or a similar one is present at the ossification center of an epiphysis or at the site of a fracture. The agent is in effect a stimulus to growth and it gives rise to speculation whether it might be a ferment-like substance needed directly or indirectly in some fundamental way with the process of growth. Possibly it is produced normally by the urinary bladder analogous to the growth hormone of the anterior pituitary.

The observations of Leo Loeb^{13, 14} in 1906 are of interest when considering the stimulus that epithelial cells may apply to connective tissue. He noted the appearance of a spindle cell sarcoma in the course of the transplantation of a carcinoma into a Japanese mouse. The epithelium apparently transmitted its stimulus to grow to connective tissue of either the original animal or of the host. As a result of the stimulus emanating from the carcinoma the connective tissue assumed a sarcomatous growth. Sections of the mouse tumor showed spindle cell sarcomata beside carcinomatous tumors.

The derivation and nature of the osteogenic tissue that forms under the influence of bladder cells and gives rise to the changes that have been described in the cartilage and perichondrium are not finally determined by our experiments. The experiments do suggest the nonspecificity of certain connective tissues which as a result of a stimulus may acquire osteogenic properties and are capable of differentiating into cartilage, bone and marrow, capillaries, osteoblasts, osteoclasts and multinucleated cells. The evidence is convincing that adult bone cells are not necessary for the development of new bone. The perichondrium which appears histologically to be similar to periosteum may respond functionally by giving rise to either cartilage, bone, or periosteum. The young connective tissue cells adjacent to the proliferating bladder epithelium and the ones that first come under their spell seem to substantiate an opinion of Maximow. He believed that connective tissue contains numerous undifferentiated mesenchymal cells, especially arranged along capillaries, capable of producing any type of connective tissue or blood cell. Our experiments do not indicate that the young connective tissues, or fibroblasts revert to an earlier type of cell (anaplasia) but rather that multipotent cells are stimulated to further differentiation into capillaries, osteoblasts, multinucleated cells, etc., by the bladder epithelium. It does not seem likely to us that the changes that have been described in our experiments are a result of

the local stimulation by bladder mucosal cells of specific undifferentiated osteogenic cells which have a widespread distribution in the body and have an inherent tendency to form bone alone.

CONCLUSION

Further experimental evidence is presented that the proliferating cells from an autogenous transplant of bladder mucosa of the dog give rise to an agent, which directly or indirectly, has the potentiality of altering the function of certain adult connective tissue.

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THE CLINICAL SIGNIFICANCE OF EXPERIMENTAL STUDIES IN WOUND HEALING*

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IT is commonly stated that the results of experimentation upon the animals commonly employed in the laboratory are not capable of transfer to man and therefore that such studies are of little importance. Usually this argument is based upon the obvious fact that not only does man differ to a great degree from even other primates, but also upon a second equally obvious fact that it is impossible to duplicate in the laboratory the exact conditions obtaining in the clinic. So, in wound healing, one says the characteristics of the phenomenon in the rat have no bearing upon what may happen in man, for they are widely differentiated species, and, following a wound, the rat does not cough, vomit, or undergo many of the vicissitudes to which man is liable.

The argument, it seems to us, overlooks the primary purpose of the experimental method, whether concerning problems in biology or in the more limited field of that subject having to do with man. It is not an attempt to duplicate in the laboratory animal phenomena as seen in the clinic—this of course is impossible—but rather to simplify the situation by reduction of the variables to the point where generalizations may be deduced from controlled observations, and which may then be tested as to their validity by observations made on man. When such generalizations are found to be true, it is then possible to interpret and to predict phenomena which would otherwise be misunderstood or unforeseen. It is with this viewpoint that we wish to consider some of the results that have been obtained in the experimental study of wound healing in our laboratories.

The attempt has been made to simplify the problem by observing one function of the healing wound which is readily measurable, namely, the tensile strength. This when considered in terms of time enables one to observe with approximate exactitude the different phases of healing, and by introducing controllable variables to determine their effect.

It became apparent at once that the curve of the velocity of the healing wound resembles that of growth in general, which in turn is like that of the growth of a population. Therefore the deduction was made in correlation with the histologic picture that we are dealing primarily and essentially, so far as the function of tensile strength is concerned, with the growth and maturation of the fibroblast. From this study, one is able to say that fibroplasia starts abruptly at the fourth day and proceeds with decreasing velocity

* The expenses of the experimental work upon which this paper is based were defrayed by Davis & Geck, Inc.

until a maximal strength for this phase of healing is reached around the twelfth to the fourteenth day and that by the sixth, approximately one third and by the eighth, approximately two thirds of this strength is obtained. This, of course, is readily checked against and correlates with surgical experience. This phase of fibroplasia has been studied in wounds of all tissues in which the normal tensile strength is greater than the maximum of the fibroplastic process and the velocity curves of fibroplasia are identical in type. A second generalization may be made to the effect that the healing of a wound in so far as the phase of fibroplasia is concerned is a phenomenon common to all tissues, irrespective of the specific differentiation primarily involved. This, while not so apparent, correlates also with surgical experience in man.

This same phenomenon, that is, fibroplasia as measured by the tensile strength, has been studied in the same tissues in several species of animals and again there appears the common lag period, and a similar growth curve reaching a maximum in the same time. This suggests that one is dealing with a basic phenomenon common not only to all tissues but to all animals tested, and leads one to question the commonly accepted view that the fibroblast involved in the healing of a wound is derived by differentiation from the already differentiated fibroblasts of the fixed tissues involved. On the contrary, the generalization is proposed that the fibroblastic phase of the healing of a wound is initiated by and derived from wandering and residual mesenchymal elements, very slightly, if at all, undifferentiated from the embryonic mesenchyme, and which are present in all tissues. This abstraction unfortunately is not susceptible of correlation in man or for the moment of direct experimental test, although much supportive evidence may be found in the studies of histogenesis of these cells both in vivo and in vitro. At least it provides a concept which is in substance that the fibroblastic phase is a characteristic basic phenomenon in itself, derived from resting undifferentiated tissue and resulting at its close in relatively undifferentiated fibrous tissue, which in its most obvious form is the scar.

We want to make the point clear, if we can, that the concept we have is not that the primary healing of a wound is due to cells derived from adjacent fixed tissues, but from cells which appear in the early exudative process, and which, by growth or differentiation, become fibrous cells, and that the scar tissue itself is not a differentiated connective tissue, but is the result of a process specific in itself.

Having thus established a normal curve for this phase of the healing of a wound, it is of importance to know what may either accelerate or decrease the velocity of the process. There are theoretically two changes that may occur; the one, the initiation of the process may be quickened or delayed, the other, the growth and maturation of the fibroblasts may be either hastened or retarded. By no means have all the possible factors which may affect this process been tested. Certain fundamental variables have been studied, however. It has been found that the initiation of growth occurs somewhat earlier in the young, but that once started it proceeds at the same rate, and that a

high protein diet accelerates to a certain degree the velocity of growth, perhaps as a result of the so called "dynamic action" of protein. This, of course, suggests that an increased metabolism may have a similar effect. Otherwise, the general and systemic factors seem to have but little or no action, unless they are so severe as to derange the chemical balance of the subject to a degree that in itself threatens its survival. This is the case in man, in the debilitated and dehydrated infant or elderly person, and in the experimental animal where conditions probably produce a delay in the initiation of fibroplasia.

A similar delay occurs as a result of any local situation which increases the exudative reaction in the wound. Infection, trauma, mechanical or chemical, the presence of dead tissue such as blood clot or suture material, act for the most part by retarding the onset of fibroplasia, rather than by inhibiting the growth of fibroblasts once initiated. These observations bring no new knowledge to the clinic but should serve to emphasize once again the necessity for the protection of tissues from damage, mechanical or chemical, for the obtaining of as perfect a hemostasis as possible and for the burying of only that quantity and kind of suture material which is essential in assuring the continuity of the wound until it attains the necessary strength. One must constantly keep in mind that the process of healing, although easily retarded, is expedited with difficulty, and that retardation is the result of anything that will intensify or prolong the exudative phase of wound healing.

We want to emphasize that the suture material customarily used by the majority of men, namely, catgut, is not only a foreign body, but a foreign body which induces exudative reaction, and, therefore, delays the initiation of fibroplasia. This is theoretical when the amount of catgut used is small. It is not theoretical if the amount of catgut placed in the wound is great. Under such circumstances, without any infection whatsoever, there will be delay in the initiation of fibroplasia and, therefore, delay in the healing of the wound.

Silk does not induce an exudative reaction and in the fine sizes that should be used is an innocuous substance. On the other hand, one has to face the fact that even in the best of our hospitals the amount of infection that occurs is appreciable and therefore it is probably good sense in most institutions to use a suture material which disappears in the presence of infection.

Fibroplasia, having produced an undifferentiated tissue as a result of the proliferation of mesenchymal elements of low differentiation in themselves, one wishes to know what further may happen to the wound. It is obvious that certain structures heal eventually with restoration of function, as do bone, tendon and fascia. In others the scar serves to preserve the continuity of an organ, such as liver, kidney, stomach and intestine, and skin. In general, however, where the function is a mechanical one, differentiation of the fibroblasts resulting from the first phase occurs to meet the functional necessity. The most striking example is in the healing of fractures with the change from fibroblastic to osteoid tissue and from this to true bone. On the

other hand, where such highly differentiated fibrous tissue is not primarily involved in the wound, then the differentiation of the fibroblast is much less marked. As a generalization one may say that the differentiation of the fibroblast involved in the first phase of healing of the wound, proceeds in the same manner and to the same result as it does in the growth and differentiation of the embryo. In the embryo the bone, for instance, is differentiated from the mesenchyme by factors we do not know with any accuracy. I doubt if we know with any accuracy what induces the differentiation of a scar as in a fracture, but in all probability it is the same factors that are involved. Therefore it may be deduced that the differentiation of simple fibroblastic tissue into highly organized connective tissue structures is governed by the same factors that control the process in the embryo to which embryologists are devoting much attention at the present time. Correlative of this is experimental evidence which we have obtained, incomplete but suggestive, that such differentiation varies according to species and directly as the rate of embryologic differentiation, or, in other words, as the rate of growth of the species concerned.

The factors other than this that may affect the rate of differentiation have been only partially studied, but again as in the first phase only the extremes of variations in diet seem to have any influence upon the differentiation of bone. The second phase of differentiation, like the first of fibroplasia, is a fundamental thing closely allied to the similar process in the embryo.

SUMMARY

From experimentation, generalizations may be derived which may receive correlative support in the clinic. Such experimental investigation of wound healing leads to certain generalizations as follows:

(1) The healing of a wound is a variant of growth, and a fundamental biologic phenomenon.

(2) The healing of a wound occurs in two phases, the first, that in which the most characteristic phenomenon is fibroplasia, and the second, that in which the fibroblasts so produced are differentiated into specific adult tissue.

(3) The first phase, that of fibroplasia, originates in and from resting, relatively undifferentiated cells closely related to the mesoblast.

(4) The second phase, that of differentiation, occurs as a result of and in the same manner as the original differentiation of these structures from the mesoblast.

(5) The healing of a wound is disturbed only by profound systemic changes, but locally healing is readily delayed by a retardation of the phase of fibroplasia as a result of an excessive exudative reaction.

(6) These generalizations are true of the common animals used for experimentation in the laboratory, including the primates, and also of man.

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DISCUSSION.—DR. DALLAS B. PHEMISTER (Chicago, Ill.).—The different varieties of connective tissue are repaired by cells derived largely from those tissues. While the early stage of repair is morphologically similar in each and may be grouped together under the heading of fibroplasia the later stages for each are different. This means that the cells active in the fibroplasia have potentialities for further differentiation according to the tissue from which they spring. Thus, newly laid down fibrous tissue from injured bone has a greater tendency to undergo metaplasia into bone than a morphologically similar tissue derived from injured fascia. Also there is not the same tendency to metamorphosis into the maturer tissue in all species. Thus, in the dog, bony union follows in all cases of fracture without loss of substance whereas non-union is fairly common in fractures in man.

DR. EDWARD L. HOWES (New Haven, Conn.).—I would like to emphasize one or two points briefly mentioned by Doctor Harvey, and especially to indicate the phase of wound healing which really can be influenced by surgical skill. Of the periods of healing which we have demonstrated, only the time when the wound depends on the sutures for strength can be affected. Tissue necrosis or infection or foreign bodies prolong its duration and delay the onset of fibroplasia. However, once generation of fibrous tissue is initiated the process of fibroplasia proceeds at a uniform rate as a general rule, despite the difficulties which delayed its onset. The infected wound remains weak, therefore, not because the rate of fibroplasia is lessened, but because the onset of the fibrous generation is delayed. This failure of fibrous tissue generation may occur only in a small portion of the infected wound, or along the entire length of the incision. In healing per primam, on the other hand, the generation of fibrous tissue nearly always begins throughout the wound at about the same time and in the shortest length of time after the injury. We as surgeons, then, have under our direct control the time when the wound will begin to gather strength—and this is the important point—that by careful surgical technic, with the minimizing of infection and contamination in the wound, and with the insertion of small amounts of suture material, we force the generation of the fibrous scar to begin in the shortest length of time after the wound is made.

The maximum strength attained by the linear scar after the period of fibroplasia depends on the thickness of that scar, for its entire mass consists solely of undifferentiated connective tissue. The strength of the scar is, moreover, in proportion to the original strength of the tissue wounded as the density and differentiation of the regenerated fibrous tissue is to the proportion and differentiation of fibrous tissue in the original tissue wounded. It follows accordingly that if the tissue is cut in such a way that its greatest strength is interfered with, as, for example, if the differentiated bundles

of fascia are cut across, a greater strength has to be regenerated ultimately by the scar through the process of differentiation than if the bundles were merely separated. Thus less strength has to be generated by healing of the wound in muscle than in fascia, for the density of fibrous tissue in the original structure is less than that in the scar. Clinical experience has for some time furnished one striking example of these facts which we can now recognize as a general principle. The McBurney incision simply divides the muscles and because the function strength of the tissues has sustained the least amount of interference the healing wound replaces this strength lost in a shorter length of time than if the muscles had been cut across with loss of all function.

DR. JOHN J. MORTON (Rochester, N. Y.).—I should like to add that Doctor Harvey has not brought out here the correlation between the size of the suture material and tissues involved in healing. I think, from a practical surgical standpoint, that this is one of the most important things which he has shown. I wish he had mentioned it in his present consideration.

DOCTOR GRAHAM.—I would like to ask Doctor Harvey what effect general anemia and intoxication, as, for example, by prolonged general anesthesia, has on these curves.

DR. SAMUEL C. HARVEY (New Haven, Conn.).—We have not tried out the effect of anemia nor experimented with the results of prolonged anesthesia. Of course one should not prophesy, but in general, in our experiments, we have been unable to find any systemic things which have any effect on this fundamental process of healing, aside from the age factor and possibly the high protein intake, which is probably, I think, related to a metabolic influence.

Replying to Doctor Morton relative to the size of catgut to tissues sutured, I have referred to this so often I hesitate to do it again. The practical thing, of course, is that there is no point at all in introducing a suture into the tissue which has greater strength than the tissue itself. That is, to use a suture of zero plain catgut in approximating fat is quite ridiculous because the fat itself has no holding power. The finest possible suture is more than sufficient to approximate fat. When it comes to approximating fascia, which is the thing we depend upon in the main, there again we have, I think, an exaggerated idea of the holding power of fascia in respect to the size of suture.

If any of you will try the simple test in your next laparotomy, of taking a double zero chromic catgut suture or one of fine silk, passing it through the edge of the fascia with a good bite and then yanking upon the suture, you will find the suture comes out of the fascia and does not break unless you have extraordinarily poor suture material. In other words, there is very little point in putting, as many do, No. 1 and 2 chromic catgut in fascia, for it is about ten times stronger than the holding strength of the fascia itself.

The reason for not using large suture is, as I have emphasized previously, that the less foreign material you put in, and catgut is definitely foreign material because it is absorbed by an exudative reaction which delays the onset of hyperplasia, the better will be the healing of the wound. Of course, this all goes back to the original contention of Doctor Halsted, for, not only the delicate handling of tissues and perfect hemostasis but also for the use of very fine suture material of a harmless nature.

A STUDY OF DEHYDRATION IN HUMANS

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IN THE course of our investigations on the water exchange of surgical patients it became apparent that a knowledge of the quantity of fluid the body loses in order to become seriously dehydrated is important. From previous studies we are able to calculate the amount of water needed by any given patient to maintain a satisfactory water balance. Some patients, however, are admitted to the surgical wards in a seriously dehydrated condition. For them, the immediate need is for more than a maintenance supply of water. A calculation of their water requirements must include an amount of water for the return of body fluids to the normal level. If it were known how much fluid is lost to produce serious effects, an allowance could be made for the water to hydrate these patients in a fairly accurate quantitative manner. A study is presented that furnished data on this problem.

It was first necessary to define some measure of serious dehydration. Clinical observations, such as the degree of dryness of the skin or tongue are factors which are difficult to grade. For our purpose it was decided that a lack of water for the normal excretion of waste materials by the kidneys was an important serious effect of dehydration and a particularly suitable one to use as an index of dehydration, since its presence would be shown in a somewhat quantitative manner by a rise in the nonprotein nitrogen of the blood to abnormal values. On this basis, the water exchange of two healthy adult male subjects was followed over a period of several days' time during part of which dehydration was produced by withholding water until the nonprotein nitrogen of the blood increased to above 40 mg. per 100 cc. There is also presented a study of the water exchange of a patient from the time of her admission to the hospital in a condition of dehydration comparable to that produced in the experimental subjects up to the time of restoration of her body fluids. This permitted a comparison of the data from the experimental subjects with that of a clinical case.

EXPERIMENTAL SUBJECTS: *Procedure*.—During the entire period of the study, the two subjects, J. N., age 26 years and R. M., age 63 years, followed a constant routine of light activity, which consisted mainly of walking to and from the hospital and a definite distance outdoors each day. Their only restriction was that they avoid sweating and keep themselves just comfortably warm by adjusting the amount of their clothing. The water exchange of these two subjects was determined by the method of Newburgh and his associates.¹ The weighing of the subjects was done on a special scale accurate to 1 Gm. The weight of all ingesta and excreta was obtained on a small

scale accurate to 0.5 Gm. An important part of the method was the calculation of the caloric expenditure of a subject from a determination of the insensible loss of weight and the urinary nitrogen. On the basis of this calculation during the first part of the preliminary period, a maintenance diet was made up for each subject and given during the remainder of the study. The foods selected were of a low water content. The mineral content of the diet was essentially constant, so that after a short period the amount of salts and end-products of metabolism offered to the kidneys for excretion was the same each day.

The preliminary period was continued until the subjects showed a fairly

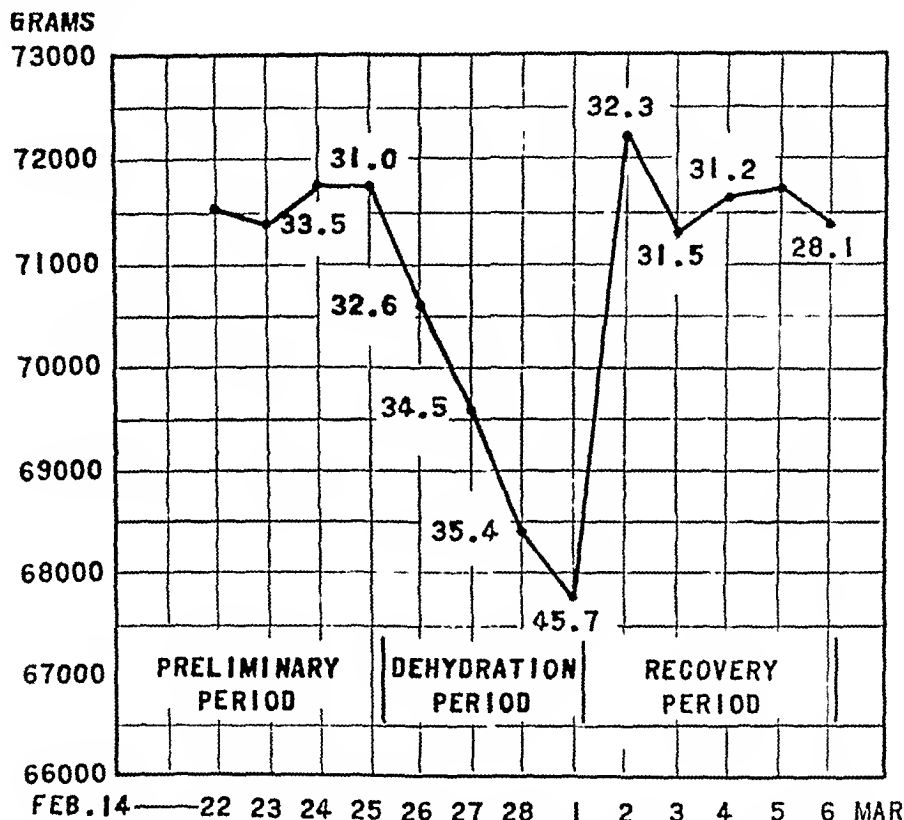


FIG. 1.—Daily weight of subject J.N., with figures along the curve indicating the blood nonprotein nitrogen in mg. per 100 cc.

constant weight. The dehydration period was then started by withholding water. The progress of the dehydration was followed by a determination of the nonprotein nitrogen of the blood at the end of each 24 hour period, which ran from 8 A.M. to 8 A.M. When this value had increased to above 40 mg. per 100 cc. the dehydration period was terminated and water was given *ad libitum*.

During the course of the study, estimations of the concentration of the venous blood by means of an erythrocyte count, a hematocrit reading (0.8 to 1.0 cc. of oxalated blood in 1 cc. graduated centrifuge tubes), and a specific gravity determination (2 cc. Gay-Lussac specific gravity bottle) were made at the same time each day. The McClure-Aldrich intradermal salt solution test^{2, 3} was also carried out on each subject daily. The result of this test in

relation to the dehydration will be reported later. The mouth temperature was determined by means of a standard Fahrenheit clinical thermometer. The effect of the dehydration on kidney function was also studied. The specific gravity of the urine was obtained by means of a specific gravity balance.

RESULTS: Changes in Weight of Subjects.—It is obvious that if an individual is fed exactly what he metabolizes, any change in his weight from day to day must be due to a retention or a loss of water. Since this was approximately the condition for the experimental subjects, the progress of the dehydration and recovery from it could be followed by noting the changes in their weight. This is shown graphically for subject J.N. in Fig. 1. The

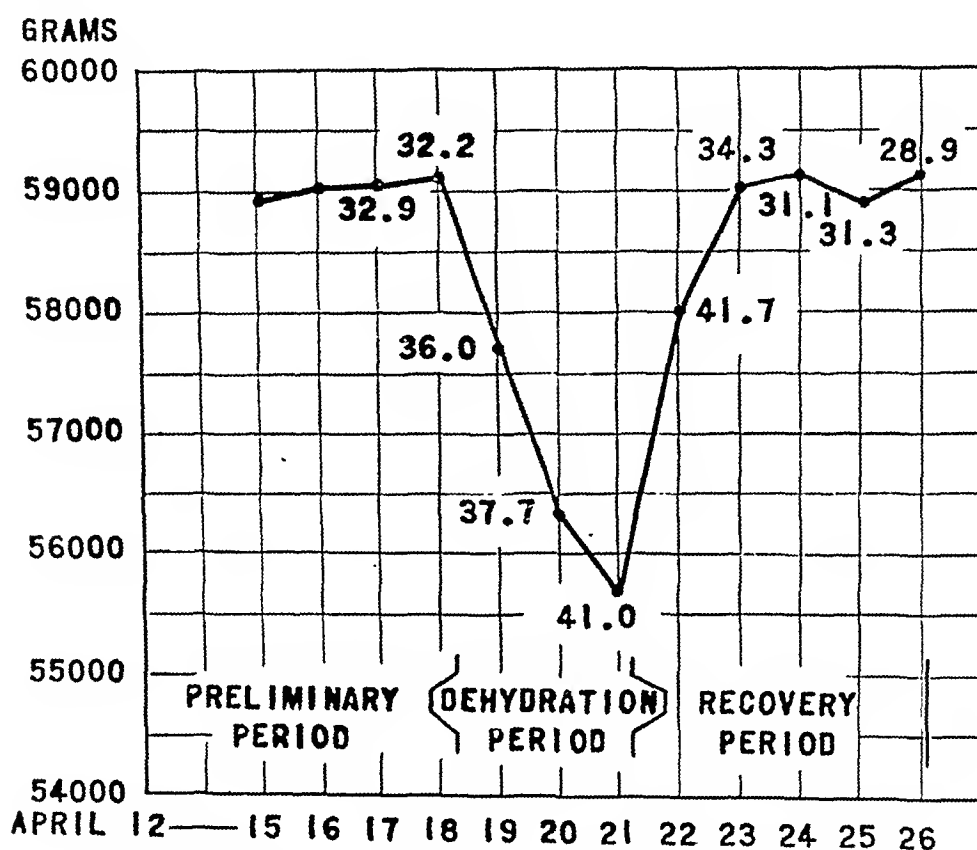


FIG. 2.—The same data for subject R.M. as shown for subject J.N. in Fig. 1.

figures along the weight curve indicate the daily nonprotein nitrogen in mg. per 100 cc. of blood. This subject lost about 4 Kg. of weight during the four days of his dehydration. On the first day of the recovery period an intake of a little more than six liters of water returned his weight to slightly above that of the preliminary period. The same data for the older subject, R.M., age 63, are shown in Fig. 2. He lost nearly 3.5 Kg. of weight when water was withheld for three days. At the end of this period he was just as thirsty as the younger subject, but was afraid that too much water would make him sick. With a comparatively moderate fluid intake, two days were required to bring his weight up to the previous level.

WATER BALANCE OF SUBJECT J.N.

The water exchange of subject J.N. is summarized in Table I.

Preliminary Period—12 Days.—The water exchange of only the last two days of this period are shown in Table I. The water drunk is an average amount for many individuals. The water content of the food is low, since it was selected for its dryness.* The water of oxidation and preformed water are endogenous sources of available water in contrast to the water drunk and the water content of the food being exogenous forms. The water of oxidation is formed on the combustion of protein, fat and carbohydrates. The total amount of water thus made available depends upon the amounts of these substances oxidized. In this instance the process furnished nearly a pint of water a day. Preformed water is the term applied in water balance to the water content of the individual's own body tissues. When body tissues are broken down and oxidized for food, as in starvation, the water content of that tissue becomes available for general purposes. Conversely, in overnutrition body tissue is formed and water is taken from the general supply to make up the water content of this new tissue. Preformed water then can be a

TABLE I
Water balance of subject J.N.

DATE, 1935	FEB.24	FEB.25	FEB.26	FEB.27	FEB.28	MAR.1	MAR.2	MAR.3	MAR.4
WEIGHT IN GRAMS OF:	PRELIMINARY PERIOD		DEHYDRATION PERIOD			RECOVERY PERIOD			
WATER DRUNK	2095	1841	0	0	0	514	6151	1698	2517
WATER CONTENT OF FOOD	261	263	296	288	259	262	273	288	288
WATER OF OXIDATION	424	435	418	367	409	406	510	481	485
PREFORMED WATER	0	-13	-26	-30	-27	-27	-17	+32	+37
WATER OF URINE	1031	1102	472	481	442	446	742	1586	1339
SP.GR. OF URINE	1.016	1.016	1.031	1.032	1.037	1.038	1.024	1.016	1.021
WATER OF STOOL	17	38	43	40	86	2	0	97	22
BLOOD	10	11	13	15	22	48	24	24	8
N.P.N. IN MG. PER 100 C.C.	33.5	31.0	32.6	34.5	35.4	45.7	32.3	31.5	31.2
WATER VAPORIZED	1348	1385	1325	1149	1295	1283	1638	1549	1562
MAX. MOUTH TEMP. °F.	98.4	98.8	98.8	98.7	99.0	99.4	98.3	98.7	98.4
TOTAL AVAILABLE WATER	2780	2526	688	625	641	1155	6917	2499	3327
TOTAL WATER OUTPUT	2406	2536	1853	1685	1845	1779	2404	3256	2931
WATER BALANCE	+374	-10	-1165	-1060	-1204	-624	+4513	-757	+396
AMOUNT OF FLUID LOST IN DEHYDRATION PERIOD: 4053 GRAMS = 5.7 PER CENT. IN RELATION TO TOTAL BODY WEIGHT OF SUBJECT 71500 GRAMS									

positive or negative factor in water balance. Since the diet was approximately that of the subject's metabolic needs, there was little undernutrition or overnutrition to deal with and preformed water was of an insignificant amount.

The water of the urine during the preliminary period was of a moderate amount and the blood nonprotein nitrogen was well within the limits of normal. The water lost in the stools was of the usual insignificant quantity when compared with the excretion of water through other channels. The blood losses shown represent amounts withdrawn for chemical studies.

The insensible vaporization of water from the skin and lungs is commonly neglected in estimations of water output. The importance of recognizing this channel of water loss is brought out by the fact that during each day of the study, excepting March 3, the output of water by vaporization from the skin and lungs was greater than the output of water in the urine. In a previous article on the water balance of surgical patients⁴ we showed that for the simple uncomplicated case this water loss varied from 1000 to 1500

* Diet of J.N. in Gm.: Bread—210, butter—70, cornflakes—40, cream 40 per cent—230, sugar—35, jelly—50, lean round beef—150, unsalted potato chips—40, mints—75, English walnut meats—30.

DEHYDRATION

Gm. per day. With fever, hyperthyroidism, or the sweating of hot and humid environments, the water vaporized generally amounted to from 1500 to 3000 Gm. per day, with an average of almost two liters per day. The figures given for J.N. during the whole period of study are a fair average for a healthy young adult weighing approximately 71.5 Kg. and carrying on a general routine of light activities.

Water balance values of 374 Gm. of hydration on February 24 and a dehydration of 10 Gm. on February 25 are examples of the small variations that occur in any individual's weight from day to day.

Dehydration Period.—No water was drunk by J.N. during the first three days of the dehydration period. On the fourth day, March 1, he was unable to eat his food because of insufficient saliva, so about two-thirds of a glassful of water had to be given with each meal, the total being 514 Gm. of water for the day. As soon as the intake of water was limited the output of water as urine diminished to about 450 Gm. per day. As the de-

TABLE II

The effect of dehydration on the concentration of the blood of subject J.N.

DATE.	1935	WATER BALANCE GM.	ERYTHROCYTES PER CU. MM.	HEMATOCRIT PER CENT	SPECIFIC GRAVITY
PRELIMINARY PERIOD					
FEB.	23	-150	5610000	49.50	1.0598
	24	+374	5110000	47.96	1.0575
	25	+10	5170000	48.50	1.0598
DEHYDRATION PERIOD					
FEB.	26	-1165	5370000	48.81	1.0601
	27	-1060	5390000	50.14	1.0623
	28	-1204	5860000	50.81	1.0631
MAR.	1	-624	6060000	50.62	1.0652
RECOVERY PERIOD					
MAR.	2	+4513	5770000	49.31	1.0604
	3	-757	5210000	47.18	1.0603
	4	+396	5380000	48.91	1.0619

hydration progressed the specific gravity of the urine increased, showing that waste materials were being excreted in greater concentrations. In spite of this effort of the kidneys, the retention of nitrogenous material in four days was sufficient to raise the nonprotein nitrogen of the blood from the average of 32.3 for February 24 and February 25 to the above normal value of 45.7 mg. per 100 cc. At this time J.N. showed all the clinical signs of a serious dehydration. His eyes were sunken; his skin was dry and hot; his tongue was completely dry and leathery, and a slight degree of fever had been present for the previous 48 hours. The occurrence of these objective findings justified our use of an elevated blood nonprotein nitrogen as an index of a serious depletion of body water. It would have been beyond the realm of experimental work to have carried the dehydration further. The total fluid loss of 4053 Gm. during this period will be discussed later.

Recovery Period.—On the first day of the recovery period, J.N. was told that he could have all the water he wanted, with an admonition to drink small amounts at first. On this first day he took in 6151 Gm. of water and began to feel much better. The distribution of this first water was of particular interest. As shown by the positive water balance of 4513 Gm. and the return of the subject's weight to slightly above the normal

level (Fig. 1), approximately two thirds of it was retained by the body to replace water previously lost. This water was not merely left for the tissues after the other water using processes had been cared for, but the tissues were given preference in their demands for water even at the expense of water for kidney function. This point is better shown in the water balance of subject R.M. and the patient B.L. and will be emphasized in commenting on their data. The urine water increase to 742 Gm. was sufficient to reduce the nonprotein nitrogen of the blood to the normal level.

On the second and third day of the recovery period, the ingestion of water was about that of the preliminary period. With no water depletion to deal with on these two days and the only preferred output of water being by vaporization from the skin and lungs, a fair amount of the total available supply of water was left for the kidneys. The water of the urine consequently amounted to 1586 and 1339 Gm. of water respectively and was of a moderate specific gravity.

TABLE III
The effect of dehydration on the kidney function of subject J.N.

DATE.	1935	WATER OF URINE GM.	SP.GR. OF URINE	TOTAL SOLIDS OF URINE GM.	NITROGEN OF URINE GM.	PRESENCE IN URINE OF PROTEIN CASTS RBC.		
PRELIMINARY PERIOD.								
FEB.	18	1274	1.015	40.8	AV. 40.1	0	0	0
	19	1431	1.012	41.2				
	20	1151	1.019	39.2				
	21	1433	1.015					
	22	1448	1.013		10.30	AV. 9.31		
	23	1012	1.016		8.70			
	24	1031	1.016	39.1	9.46			
	25	1102	1.016		8.80			
DEHYDRATION PERIOD								
FEB.	26	472	1.031	31.8	6.32	0	0	0
	27	481	1.032	36.6	7.00	0	0	0
	28	442	1.037	38.0	8.08	SL. TR.	+	0
MAR.	1	446	1.038	44.1	10.64	TRACE	+	+
			1.041					
RECOVERY PERIOD.								
MAR.	2	742	1.024	48.1- EXCESS	8.0	14.48- EXCESS	5.17	SL. TR.
	3	1586	1.016	40.8	10.32	SL. TR.		
	4					SL. TR.		
	5					0	0	0

Blood Concentration During Dehydration.—In Table II are shown the data obtained from studies on the concentration of the venous blood of subject J.N. During the dehydration period the changes in the erythrocyte count, the hematocrit and the specific gravity furnished definite evidence of a diminished blood volume. With an adequate intake of water the data showed that the blood volume was rapidly restored to the previous level.

Kidney Function During Dehydration.—Significant data on the kidney function of J.N. during the important period of study are shown in Table III.

On the diet fed the total solids excreted in solution by the kidneys during the preliminary period averaged 40.1 Gm. per day. As a result of the insufficient supply of available water, on the first day of the dehydration period 31.8 Gm. of waste materials were excreted, giving a retention of 8.3 Gm. The amount of material to be excreted by the kidneys on the second day was the average of 40.1 Gm. from the diet, plus

the 8.3 Gm. of retention plus the salts set free when body water was lost as a result of the dehydration.* The conditions were thus becoming increasingly severe for the kidneys. With a greater concentration of urine, however, 36.6 Gm. of total solids were excreted on this second day. With the same vicious circumstances continuing, on the last day of the dehydration period the specific gravity of the 24 hour urine specimen was 1.038 and 44.1 Gm. of solids were excreted. A two-hour specimen of urine during this day showed a specific gravity of 1.041, which is the highest specific gravity observed by us for a urine specimen free of sugar and containing no more than a trace of protein. Ordinarily we consider kidneys to show normal function when they can concentrate urine to a maximum specific gravity of from 1.029 to 1.032.⁵ The degree of dehydration produced, forced the kidneys of this healthy young man to an effort well above the normal maximum, but it was not accomplished without some evidence of kidney damage, J.N.'s urine on the last day of the dehydration period showing a trace of protein and more than the usual number of casts and erythrocytes. Even with a plentiful supply of water, four days were required before the proteinuria disappeared.

During the dehydration period the values for the total solids of the urine when compared to the average of the preliminary period showed a retention of 9.9 Gm. A similar calculation of the urinary nitrogen figures showed the retention to be 5.20 Gm., which accounts for more than half of the total solids retained, and which a more complete study of the effect of dehydration on kidney function by Dr. R. H. Freyberg of the Department of Internal Medicine¹⁶ showed to be practically all urea nitrogen. A urine water output of 742 Gm. on the first day of the recovery period was sufficient for the excretion of the daily waste products and nearly all of the previous retention.

An interesting calculation can be used to show how the nitrogen retention of 5.20 Gm. during the dehydration period accounted for the increase in the nonprotein nitrogen of the blood from the average of 32.3 mg. per 100 cc. for the last two days of the recovery period to the abnormal value of 45.7 mg. per 100 cc. at the end of the dehydration period. This increase of 13.4 mg. per 100 cc. was not confined to the blood alone, but was spread equally through all body fluid. J.N. weighed approximately 71.5 Kg. Since he was somewhat dehydrated, his total fluid content amounted to approximately 60 per cent of his total body weight, or 42.9 Kg. If the 13.4 mg. per 100 cc. are multiplied by 42.9 the result is 5.75 Gm., a close agreement with the 5.20 Gm. of nitrogen retained.

WATER BALANCE OF SUBJECT R.M.

The conditions for the study of R.M. were slightly modified from those of J.N. The diet† was of a simpler arrangement and had sufficient fluids in it to enable R.M. to eat the food without water during the dehydration period. Then, in order to shorten the time for dehydration, which after the first day is rather an uncomfortable period, the subject maintained his customary activity, but spent part of the day and slept at night in a room kept at a temperature of 85° to 90° F. Slight sweating occurred and the water vaporized was greater in amount.

The water balance data of R.M. are shown in Table IV.

Preliminary Period.—7 Days.—With the exception of the low water content of the food and a blood loss, the water balance figures of April 17 and 18 are typical examples of normal water exchange.

* Since in this instance the dehydration was largely the result of the continuous insensible vaporization of water from the skin and lungs, the loss of body fluid substance with the water was negligible.

† Diet of R.M. in Gm: Cream 40 per cent—240, milk—200, unsalted crackers—60, butter—60, jelly—75, cheese—120.

Dehydration Period.—At the end of three days' abstinence from water, R.M.'s depletion of body fluids was sufficient to produce all the signs of serious dehydration, and his retention of urine wastes was great enough for the nonprotein nitrogen of the blood to have increased from 32.2 to 41.0 mg. per 100 cc. With a daily total available water of only 651 Gm., the water of the urine for this period was less than 400 Gm. a day. The specific gravity of this urine ran from 1.029 to 1.032, which is evidence of normal concentrating power of the kidneys.⁶ The total of the negative water balance figures for the three days of dehydration amounted to 3397 Gm. This fact will be discussed later.

Recovery Period.—On the first day of the recovery period, R.M. was told that he could have all the water he wanted. He was afraid that too much water would make him sick, and as a result he only partially satisfied his thirst. The effect of this low water intake on the recovery from dehydration emphasized an important fact concerning water for the restoration of body fluids, the fact being shown as follows:

TABLE IV
Water balance of subject R.M.

DATE 1935	APR.17	APR.18	APR.19	APR.20	APR.21	APR.22	APR.23	APR.24	APR.25
WEIGHT IN GRAMS OF:	PRELIMINARY PERIOD	DEHYDRATION PERIOD				RECOVERY PERIOD			
WATER DRUNK	1457	1652	0	0	0	2392	2817	2558	1370
WATER CONTENT OF FOOD	362	362	363	363	363	359	359	365	363
WATER OF OXIDATION	304	310	310	310	310	310	310	310	310
PERFORMED WATER	-26	-22	-22	-22	-22	-22	-22	-22	-19
WATER OF URINE	921	818	349	395	273	154	936	1785	937
SP.GR. OF URINE	1.012	1.012	1.029	1.031	1.032	1.031	1.016	1.008	1.013
WATER OF STOOL	63	0	0	66	0	38	108	76	37
BLOOD	10	5	45	11	18	61	12	13	13
N.P.N. IN MG. PER 100 C.C.	32.9	32.2	36.0	37.7	41.0	41.7	34.3	31.1	31.3
WATER VAPORIZED	1040	1477	1687	1490	1016	545	1364	1237	1282
MAX. MOUTH TEMP. °F.	98.3	98.4	98.4	99.4	99.0	98.4	98.2	98.6	98.0
TOTAL AVAILABLE WATER	2097	2302	651	651	651	3039	3464	3211	2024
TOTAL WATER OUTPUT	2034	2300	2081	1961	1307	798	2420	3111	2269
WATER BALANCE	+63	+2	-1430	-1311	-656	+2241	+1044	+100	-245
AMOUNT OF FLUID LOST IN DEHYDRATION PERIOD 3397 GRAMS									
IN RELATION TO TOTAL BODY WEIGHT OF SUBJECT 59000 GRAMS = 5.8 PER CENT.									

On April 22, the first day of the recovery period, R.M. drank 2392 Gm. of water. In spite of this, the water of the urine on this day was only 154 Gm. compared to 273 Gm. on the previous day, when no water was drunk. The answer to this apparent paradox was simple. The water balance figures for April 22 showed that the tissues took up 2241 Gm. of water to replace fluid lost during the dehydration period. This was corroborated by a weight gain for the day of 2256 Gm. Under these circumstances there was little water left for the kidneys, even though waste products normally excreted by them were accumulating in the blood. From these data, it is clearly evident that water for the restoration of body fluid is a "preferential process," that is, water will be used to satisfy this need before water becomes available for kidney function. Thus in a dehydrated patient, a satisfactory urine output will be obtained only when the preferential processes—water for the restoration of body fluid and water for vaporization from the skin and lungs—have been taken care of.

On the second day of the recovery period, April 23, the water balance figures showed a hydration of only 1044 Gm. When this amount is subtracted from the total available water of 3464 Gm., sufficient is left to take care of all of the other water using processes and leave enough for 936 Gm. of urine water. With this water the kidneys were able to

excrete most of the previously retained waste materials, the blood nonprotein nitrogen falling to within 2 mg. per 100 cc. of the preliminary period level. With the fluid depletion already restored, the water balance for April 24 and 25 showed normal exchanges.

The Amount of Fluid lost To Produce Serious Dehydration.—The determination of this point was the primary object of the investigation. As far as could be told from clinical observations and particularly from the rise in the nonprotein nitrogen of the blood, the dehydration was carried out to the same degree in both subjects and was about as severe as they could tolerate. In Table I the fluid loss of 4053 Gm. by J.N. amounted to 5.7 per cent of his total body weight. For R.M., Table IV, the fluid loss of 3397 Gm. amounted to 5.8 per cent of his total body weight. The difference in the ages of the adult subjects did not affect the results. The figures seem to be remarkably consistent, but are not surprisingly so considering the close correlation of other biologic facts in different individuals and even between different species.

Because it was more simple, we presented the loss of body fluid in terms of per cent of total body weight rather than in per cent of total body water. Considering the total water content of the body to be 65 per cent of the total weight and recalculating our figures, J.N.'s serious effects were due to a loss of 8.7 per cent of his total body water and R.M.'s similarly to a loss of 8.8 per cent. These results are in entire accord with the data from the experimental dehydration of animals by Balcar, Sansum and Woodyatt,⁶ Nothwang,⁷ Keith⁸ and Rubner,⁹ the latter stating that an animal can lose scarcely 10 per cent of its water content without serious consequences.

Water Balance of a Dehydrated Patient.—The following is an account of a water balance study on a patient who entered the hospital in a condition of dehydration which appeared clinically to be of about the same degree as that produced in the experimental subjects. The study began two hours after the patient's admission to the ward and was continued until the water balance was back to normal. We were particularly interested in knowing whether the recovery from dehydration followed along the same lines as that of the experimental subjects and just what the fluid loss had been in relation to the patient's total body weight.

SUMMARY OF CASE.—B.L., a woman of 48 years of age, was admitted to the surgical ward on March 29, 1935, with a complaint of abdominal pain and distention, and obstipation of 48 hours' duration. Vomiting had occurred twice during that time. No food or fluid had been taken in the 30 hours previous to admission. The past history revealed a lower abdominal operation 12 years previously for intestinal obstruction. On May 26, 1934, a left pyelolithotomy and nephrostomy had been done for stones and on June 20, 1934, a right nephrectomy was performed for a calculus pyonephrosis.

On physical examination the patient appeared to be in moderate pain and was definitely dehydrated. Her lips were dry and her tongue showed only a slight amount of moisture at the edges. The abdomen was moderately distended, was tympanitic and tender in the lower half. On admission the leukocyte count was 19,000 per cc. of blood and the hemoglobin was 104 per cent (Sahli). No urine could be obtained on catheterization. The nonprotein nitrogen was 61.2 mg. per 100 cc. of blood. The blood chlorides were 558 mg. per 100 cc. (plasma). A flat roentgenogram of the abdomen showed a distention of what appeared to be isolated loops of small bowel.

In view of the damaged remaining kidney, the dehydration, the oliguria and the high value for the blood nonprotein nitrogen, a decision was made to treat the obstruction conservatively for the time being. The patient was made comfortable with opiates. A Wangenstein duodenal suction apparatus was started and heat was applied to the abdomen. Intravenous fluids were given by one of us who stayed in the room with the patient during the day. An assistant stayed with the patient during the 12 hour night period. In this way the abdominal condition was closely followed and the water exchange accurately determined. During the time of our observation the abdominal condition did not materially change.

The water balance of the patient during the three and a half days of the hydration period is shown in Table V. The important consideration in the water requirements of this patient was that sufficient fluid be available for all the preferential process, that is, water for vaporization and for the restoration of the tissue deficit, plus an excess permitting

TABLE V
Water balance during hydration of patient B.L.

DATE. 1935	MAR.29	MAR.30	MAR.31	APR. 1
WEIGHT IN GRAMS OF:	12 HOURS			
INTRAVENOUS FLUID	3977	3912	6565	4915
RETAINED ENEMA FLUID	0	0	718	0
WATER OF OXIDATION	150	350	300	275
PREFORMED WATER	100	220	200	200
URINE	31	406	4884	4598
SP.GR. OF URINE	1.020	1.013	1.011	1.006
BLOOD N.P.N. MG. PER 100 C.C.	63.8	73.5	48.3	37.9
STOOL	0	0	7	0
BLOOD	0	10	12	6
SPUTUM	0	0	30	0
GASTRIC DRAINAGE	161	306	120	0
INSENSIBLE LOSS	595	2470	1665	1586
MAX. MOUTH TEMP. °F.	100.5	102.3	98.4	100.0
TOTAL AVAILABLE WATER	4227	4482	7783	5390
TOTAL WATER OUTPUT	787	3192	6718	6190
WATER BALANCE	+3440	+1290	+1065	-800
AMOUNT OF FLUID RESTORED IN HYDRATION PERIOD 4995 GRAMS				
IN RELATION TO TOTAL BODY WEIGHT OF PATIENT 82000 GRAMS = 6.1 %.				

a fairly large urine output. The following phases of her water exchange were of particular interest.

Intravenous Fluid.—Because the patient was in need of water and showed only a slight decrease in blood chlorides at the time of her admission, the intravenous fluid given was a 5 per cent glucose solution with the exception of 1559 Gm. of physiologic saline solution on April 1. This salt solution was given because on the latter part of the previous day the blood chlorides were down to 437 mg. per 100 cc. (plasma). This choice of fluid for parenteral administration was in accordance with our opinion that the way to supply an abundance of available water to the body is to give a 5 per cent glucose solution. The glucose is oxidized and the water is left for all purposes. A saline solution is given only when sodium or chloride ions are needed, as shown by and followed by blood chemistry studies. An excess of salt solution may be the cause of edema. The glucose solution readily restored the depleted body fluids of this patient.

Water Balance of First and Second Day of Hydration.—These two days are considered together because they had several features in common. The data shown for March 29 ran from 8 P.M. to 8 A.M. the following morning, and thus covered only the latter 12 hours of the usual 24 hour period. During the 36 hours of March 29 and 30, the total available water amounted to 8709 Gm. Most of this water came from 7889 Gm. of intravenous fluid. In spite of this fairly large supply of fluid, the urine output for this period amounted to only 437 Gm. At the specific gravities shown for this urine, only a small amount of waste material could be excreted, and as a result the nonprotein nitrogen of the blood increased from 61.2 mg. per 100 cc. at the time of admission to 73.5 mg. The maximum concentration of the urine to a specific gravity of only 1.020 under the conditions of dehydration present was well below the normal of 1.029 to 1.032 and was definite evidence of impaired kidney function.⁶ The question of whether a calculus obstruction of the only remaining ureter might be responsible for the low urine output of 437 Gm. was raised, but was quickly abandoned when the other water losses of the period and the experience from the dehydrated subjects was considered. We have frequently emphasized the fact that the kidneys do not have the privilege of taking a share of the total available water for their work, but function with the water left after all the other water using processes have been cared for. An inspection of the water exchange for the 36 hour period showed that the low urine volume here was no exception to the rule. The total amount of available water was 8709 Gm. The insensible vaporization of water is a preferential process which took 3065 Gm. The studies on the subjects J.N. and R.M. showed that water to the tissues to replace depleted body fluids is also a preferential process. In this instance it amounted to 4730 Gm. The sum of the water vaporized and the water to the tissues was 7795 Gm. From the 8709 Gm., this left only 914 Gm. of water for other purposes. Subtracting from this the 467 Gm. fluid loss in gastric drainage and little was available for the kidneys. The low output of urine was not the fault of the patient, or the patient's kidneys. We had taken over the job of supplying a satisfactory amount of available water and although 7889 Gm. of a 5 per cent glucose solution were given intravenously the amount was inadequate to meet the actual water requirements.

Water Balance of Third and Fourth Day of Hydration.—Profiting by the experience of the first two days of the hydration period, the total supply of available water for the third day was stepped up to 7783 Gm. by increasing the intravenous fluid to 6565 Gm. The tissue thirst having been largely cared for on the two preceding days the water balance showed the hydration to amount to only 1065 Gm. The insensible loss of water was 1665 Gm. When the total of these two factors is subtracted from the total available supply, 5053 Gm. of water is left for other purposes. The gastric drainage, the blood, and the stool loss was small, so the urine volume was 4884 Gm., and the blood nonprotein nitrogen was reduced to 48.3 mg. per 100 cc.

Since the water exchange of March 31 was entirely satisfactory the same plan of treatment was carried out on April 1. Intravenous fluids of 4915 Gm. provided a large part of the 5390 Gm. of available water. A negative water balance showed that an additional 800 Gm. of water previously taken up by the tissues also became available. As a result, after accounting for the insensible loss of water, the urine output was 4598 Gm. and the nonprotein nitrogen of the blood was down to a normal level.

Fluid Lost by Patient to Become Dehydrated.—The water balance figures of Mrs. B.L. for the three and a half days showed a hydration of 4995 Gm. This represented the amount of water added to her body to restore tissue fluids. There is every reason to believe that it represented the quantity of fluid lost by the patient in becoming dehydrated. This quantity amounted to 6.1 per cent of her total body weight. This was a close correlation with the 5.7 and 5.8 per cent loss by the experimental subjects.

COMMENT

Dehydration of varying degrees is commonly seen in sick individuals, and restoration of the depleted fluids is one of the first considerations in their

treatment. Because in many surgical conditions there is an interference with the normal ingestion of water, the hydration of these individuals is dependent upon the parenteral administration of fluid, and therefore is governed by the surgeon. If it were known how much fluid is lost to produce serious effects, in the calculation of water needs an allowance could be made for the water to restore body fluid in a fairly accurate quantitative manner.

To investigate the problem, the first requirement was some measure of dehydration to serious effects. When the total output of water is greater than the supply, the kidneys only get whatever water is left over after all the other channels of exit have been satisfied. Since a definite minimum amount of water is needed by them to excrete every gram of solids,¹⁰ retention of urinary wastes is an important result of a deficient supply of water. Retention is prevented for a time by a release of body water. When it is more important for the organism to keep what water it has rather than to furnish the kidneys with amounts needed by them to carry out their full function, urine wastes begin to accumulate. This point may be properly regarded as the beginning of serious dehydration. Its presence can be shown in a somewhat quantitative manner by a rise in the nonprotein nitrogen of the blood to abnormal values.

From a water balance study involving the dehydration of two normal adult subjects and the hydration of a patient who showed moderately severe effects of depleted body water, it was apparent that with a loss of body fluid amounting to about 6 per cent of the total body weight an individual is at the beginning of serious dehydration. At this point, the clinical signs of dehydration will be well established; the blood will be concentrated, and the urine output insufficient to maintain normal kidney function so that the nonprotein nitrogen of the blood will be above normal. The effort of the kidneys to rid the body of waste materials under the adverse circumstances may result in kidney damage, as shown by the occurrence of protein, casts and erythrocytes, in the urine. All of these findings indicate the urgency of a plentiful supply of water in as short a time as possible.

For our subjects only water was needed to replace the depleted body fluids. This is not the usual condition in dehydrated patients.¹¹ Many of them, as by vomiting, will have lost water and the materials normally held by it in solution, chiefly sodium and chloride ions. These losses will be shown by appropriate blood chemistry studies. A sodium chloride solution must then be given, but only until the blood studies show the loss of these electrolytes to have been corrected. Many times on an active surgical service fluids are given intravenously, not to treat dehydration, but to prevent dehydration. The patient, often as a result of an operation, is not permitted to or cannot drink sufficient water. Water is needed to maintain a normal water balance, but there is no need for sodium chloride and an excess of salt solution may be the cause of edema. If a 5 per cent glucose solution is given to these patients, the glucose will be oxidized and the water left available for all purposes.

The important fact in the recovery of our subjects from dehydration was

that the tissues took nearly all of the first water given to replace lost body fluid. This fact is readily applicable to the treatment of dehydrated patients. From previous studies^{12, 4} we emphasize that a fairly accurate calculation of the amount of fluid needed to maintain a satisfactory water balance in any given patient can be made by the following allowances:

(1) Water for urine: At least 1500 cc. per day for the sick surgical patient.

(2) Abnormal losses: Such as vomitus or drainage from intestinal or biliary fistulae. These losses should be measured and the amounts recorded on the patient's chart.

(3) Water for vaporization from the skin and lungs: This will vary from 1000 to 1500 cc. per day for the simple uncomplicated surgical case. With the increased heat production of fever or hyperthyroidism, or the sweating of hot and humid environments, this loss will amount to from about 1500 to 3000 cc. per day with a safe average of two liters a day.

If, for the dehydrated patient, only the above three channels of water loss are considered, the tissues will take water for the restoration of normal fluid content and the kidneys will suffer accordingly. Therefore, for the dehydrated patient an additional allowance must be made:

(4) Water for the restoration of depleted body fluids: For patients showing the beginning signs of serious dehydration—a dry tongue, scanty urine, blood nonprotein nitrogen increased—a fair estimation of this water need can be made on the basis of 6 per cent of the total body weight. Examples for individuals of various weights would be as follows:

Weight of patient Kg.	6 per cent Gm. or cc.
100	6000
80	4800
60	3600
40	2400
20	1200

Lesser and greater degrees of dehydration than that produced by us are commonly met with in sick individuals.^{13, 14} From experience, we have been able to estimate the degree of their dehydration on the basis of the findings in our subjects and thus to vary the 6 per cent figure to fit the individual need.

From these calculations of water requirements, it is clearly evident that for the dehydrated patient the usual two or three liters of fluid are entirely inadequate, in many instances from six to nine liters being actually needed. In our hands, the management of the water balance of the sick patient by figures based on facts has yielded gratifying results.

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RESPIRATORY PHYSIOLOGY IN THORACIC SURGERY*

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MONTREAL, CANADA

FROM THE DEPARTMENT OF SURGERY, MC GILL UNIVERSITY, MONTREAL, CANADA

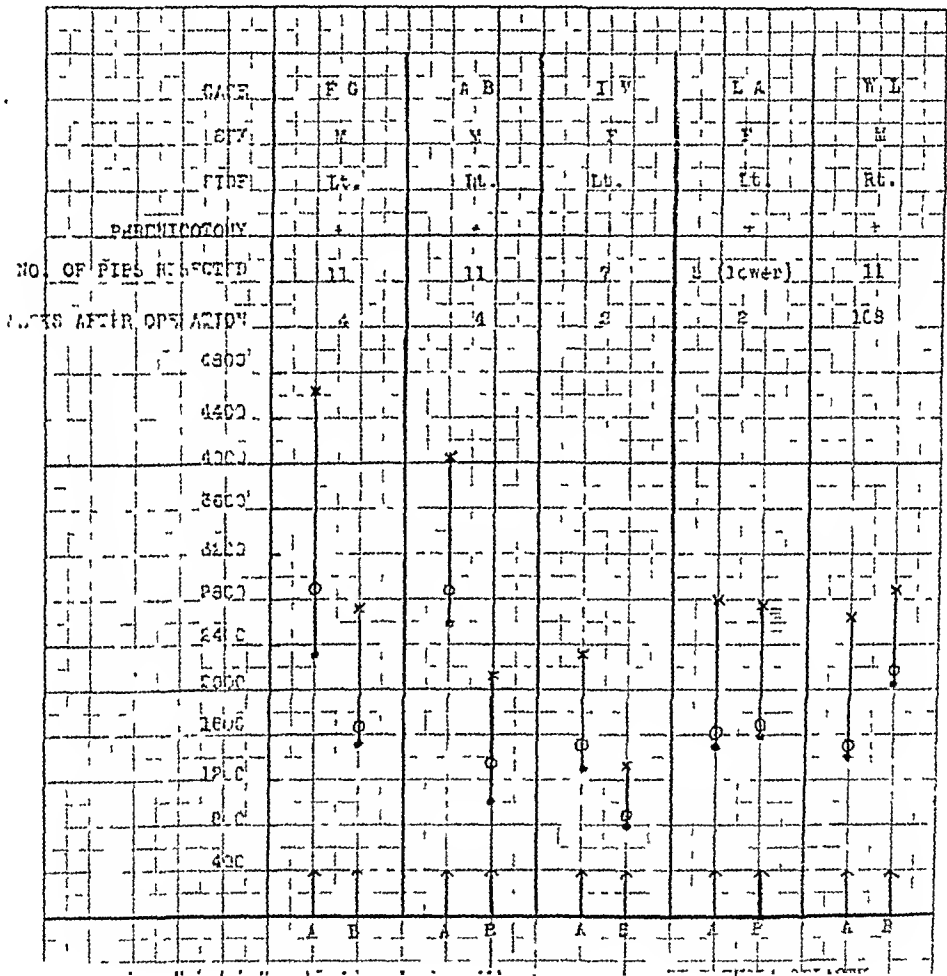
IT IS not the object of this paper to describe the physiologic changes that result from all the more common thoracic operations, but rather to demonstrate certain of the respiratory readjustments that follow extrapleural thoracoplasty. Indeed, it is almost amazing, when one reads the literature of thoracoplasty, to find the meager amount of recorded data that deal with the altered respiratory function. In the main, the results of thoracoplasty are looked for in an improvement of the clinical condition of the tuberculous patient—the diminution or absence of sputum, fall of pulse and temperature, freedom from hemoptysis, absence of cough, *etc.* Indeed, from the clinical standpoint, there is still much to be said for bed rest or artificial pneumothorax, as opposed to thoracoplasty, even in favorable cases.¹ It is natural, then, that the therapeutic value of this operation in tuberculosis should be the main issue. Nevertheless, the functional results of such a procedure are not to be overlooked, especially when it becomes apparent that thoracoplasty can change a tuberculous patient, who at bed rest has no dyspnea and indeed little dyspnea on moderate exertion, into a chronic invalid from a respiratory point of view, even though the cough, sputum, bacilli, *etc.*, have been eliminated. If it were left to the patient, it is problematical between which he would choose. From the surgeon's standpoint, his problem in any given case is quite clear. Can the disease be arrested without making the patient worse off physiologically than he was before?

Strange as it may seem, and it is now over 20 years since thoracoplasty for pulmonary tuberculosis came into being as a standard operation, the functional capacity of the apparently arrested cases is not accurately stated. The latest volume dealing with thoracic surgery² records the results of over 3,000 thoracoplastic cases collected from the literature, yet a detailed account of the extent of the disease, the amount of rib resection, and the patient's absolute functional capacity after operation, is not to be found except in small isolated accounts. In an attempt, therefore, to record more detailed facts about such cases than is contained in the usual discharge summary of thoracoplasty cases, the following investigations are set forth.

Before recording the facts observed, a few words are necessary to point

* Read before the American Surgical Association, Boston, Mass., June 7, 1935.

out the impairment of function in ordinary tuberculous cases, more particularly those that are subjected to operation. It has long been recognized that vital capacity is impaired, but in the early stages its reduction is hardly measurable since the normal standards as calculated from the surface area, *etc.*, are relatively unsatisfactory. Methods are now available whereby the total lung capacity, functional residual air and the residual air³ can be measured with considerable accuracy. From them, the ratio of the functional residual air to the total capacity can be determined, which is found remarkably constant in normal individuals. The limits within which this ratio may fluctuate have

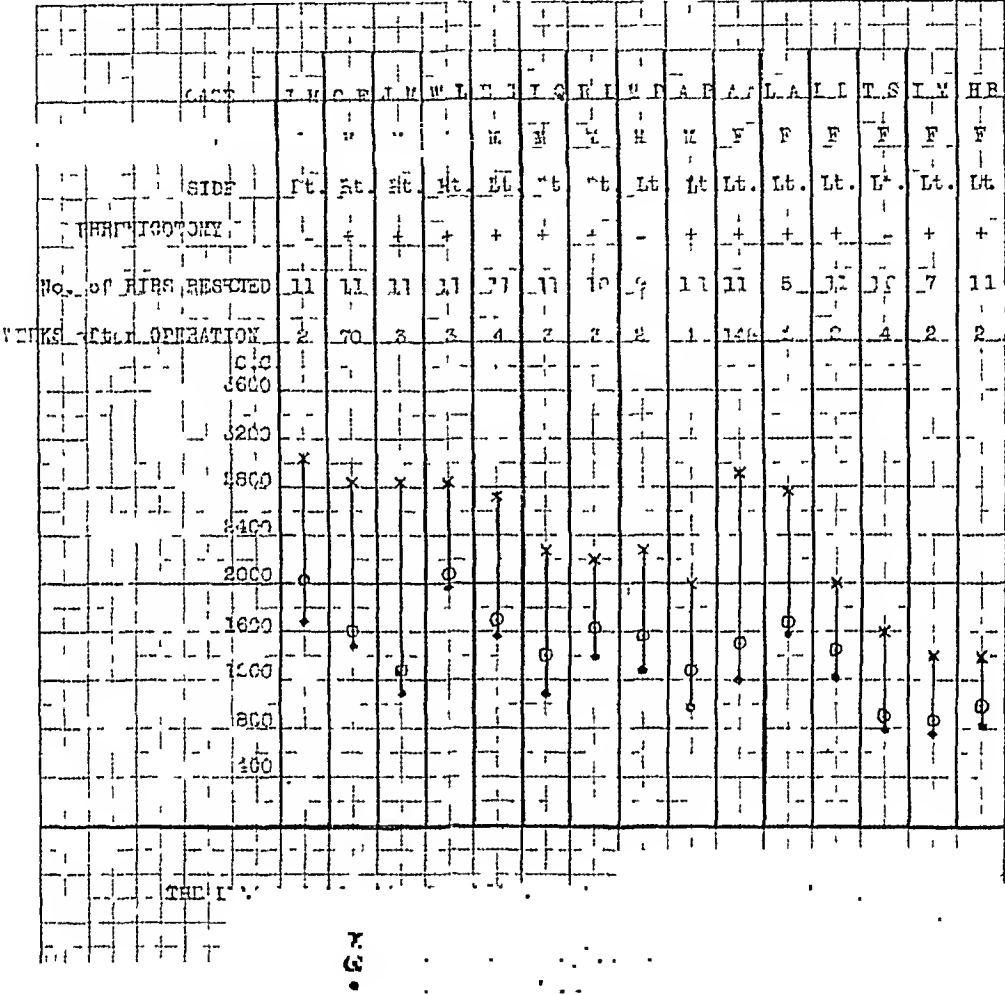


GRAPH 1.—The lung volume and its subdivisions in five cases of pulmonary tuberculosis before and after thoracoplasty.

been established by Hurtado and Boller.⁴ With minimal lesions the ratio is at the lower limit of normal, and with more extensive disease it becomes greatly increased. Practically all patients that are subjected to thoracoplasty show at least a slight elevation in the ratio before operation. A more de-

tailed account of the respiratory function in tuberculosis will be published shortly.⁵

The Lung Volume and Its Subdivisions after Thoracoplasty.—The following observations have been made on 15 cases of tuberculosis that were admitted to the general surgical wards of the Royal Victoria Hospital for the performance of extrapleural thoracoplasty. In five instances (A.B., E.G., W.L., I.M., L.A.) the lung volume and its subdivisions have been measured before and after operation, while in the remaining ten cases the determinations



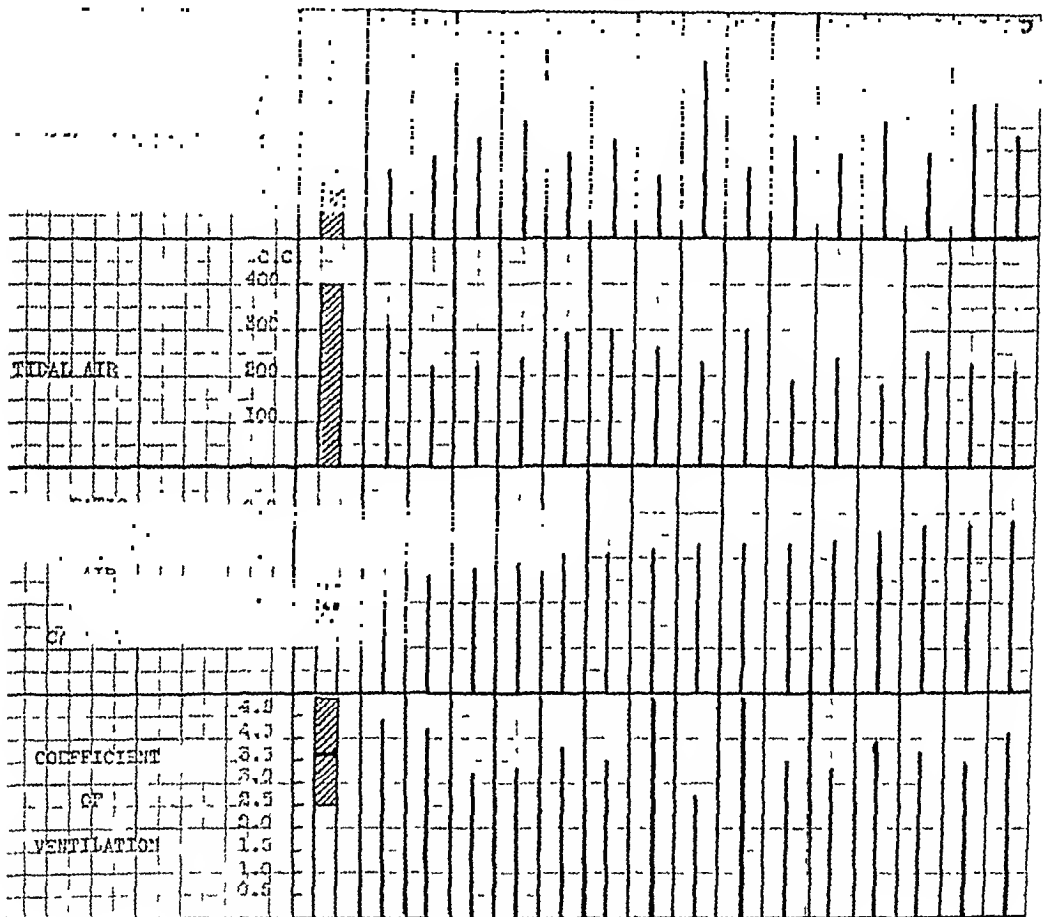
GRAPH 2.—The lung volume and its subdivisions in 15 cases of pulmonary tuberculosis after extrapleural thoracoplasty.

were made only after operation. Except in three instances (C.F., A.B., A.A.) all the measurements have been made within a few weeks of the operative procedure (Graphs 1 and 2).

A great reduction in lung capacity was noted. The total capacity was reduced in every instance to less than 3,000 cc., and in two female patients (I.M. and H.B.) to 1,400 cc. The functional residual air was likewise very definitely reduced and, since the measurement of this quantity is the actual amount of functional lung collapsed by this operation, it is the most important figure to be determined accurately. The functional residual air

and the residual air follow each other very closely. At the lower levels between 800 and 900 cc., the reserve air has become reduced to a few cubic centimeters. The greatest reduction took place in the complementary and reserve air, which is shown in the diminution of the vital capacity (Graph 3).

The ratio of the functional residual air to the total capacity in all instances was well above the average normal. The greater the ratio above the normal, the greater the loss of pulmonary efficiency, for "the efficiency of the pulmonary ventilation would appear to rest upon the relationship between the residual air and the total capacity."⁶



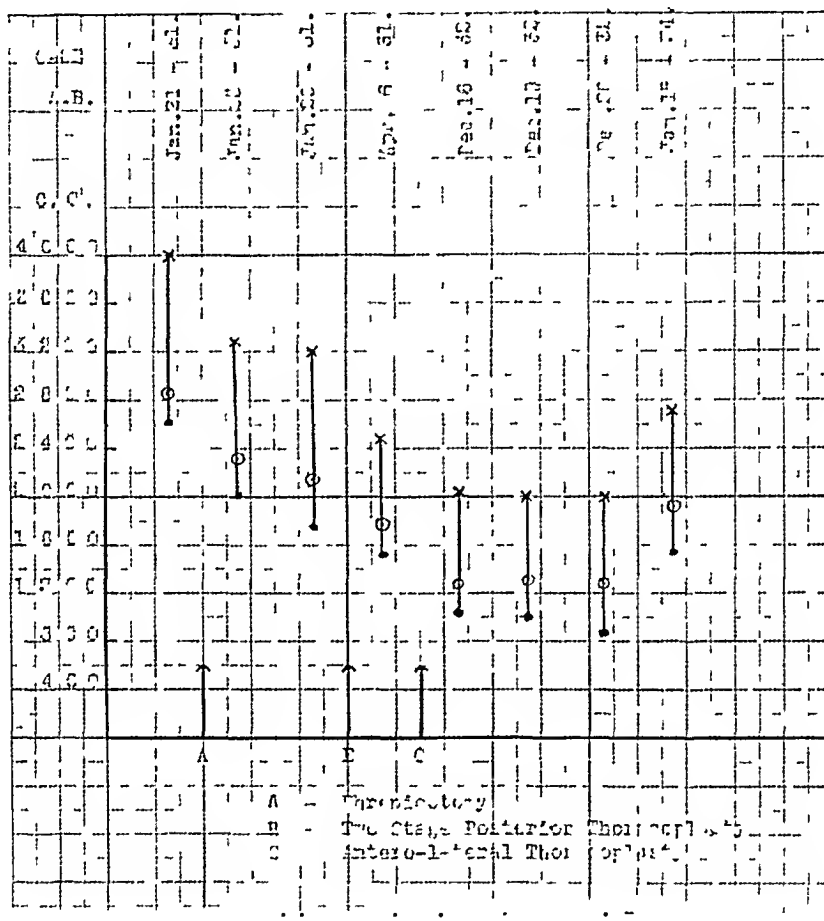
PULMONARY VENTILATION AFTER THORACOPLASTY

GRAPH 3.—Respiratory rate, tidal air, ratio of functional residual air to total capacity and the coefficient of ventilation in 15 cases of pulmonary tuberculosis after thoracoplasty.

In those instances where a period of time has been allowed to elapse between the thoracoplasty and the lung volume determinations, there was a moderate total capacity but still a greatly disturbed ratio (cases A.B., A.A., C.F.). Undoubtedly, the contralateral lung does increase in volume, when the total capacity has risen 750 cc. in a period of two years after operation and this without the resolution of any known exudate in the healthy lung. The effect of phrenicotomy and three thoracoplasty operations in reducing the various subdivisions of the lung volume was definitely noted (Graph 4).

Hemorespiratory Exchange.—As the ratio of the functional residual air to the total capacity rises, there is, in a general way, a fall in the tidal air and an increase in the respiratory rate. Any impairment of total oxygen absorption would be clearly demonstrated by a deficiency in the respiratory coefficient, and this really is a vital respiratory function, more so than the total ventilation. The coefficient of ventilation was measured by collecting the expired air in a Douglas' bag over a period of six minutes. In all instances the coefficient was found to lie within the normal variations.

The Alveolar Air.—On account of the great diminution in the tidal air,



GRAPH 4.—The lung volume and its subdivisions in a case of pulmonary tuberculosis after phrenicotomy, and thoracoplasty done in three stages.

it was found quite impossible to measure the alveolar air with any degree of accuracy. The pressure of CO_2 , as determined from the arterial blood, was within normal limits except in two instances.

The Arterial Blood.—On nine occasions, the arterial blood gases were analyzed after thoracoplasty. In only two instances was the oxygen saturation above 90 per cent. This is of some importance when one considers that the ordinary tuberculous patient, without acute pneumonic disease, has a normal saturation, as well as a patient under pneumothorax therapy, provided the refills are not too massive. The carbon dioxide content of the serum was in each case within normal limits.

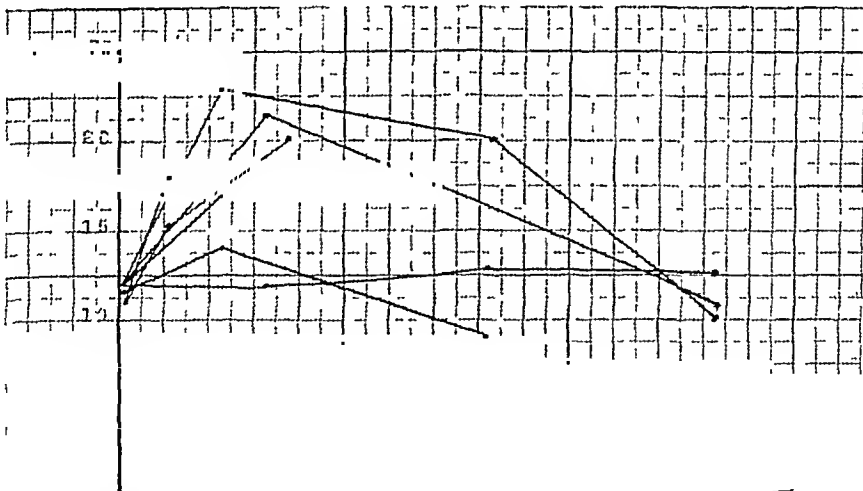
The Hemoglobin.—As might well be expected, the hemoglobin, as measured by the oxygen capacity of the whole blood, was definitely below the normal in those cases where the determination was made shortly after the operation. In only one instance was the hemoglobin increased some months after thoracoplasty, as is so often the case following pneumothorax therapy.⁷

The Metabolic Rate.—The metabolic rate following thoracoplasty follows the same changes as does any case of pulmonary tuberculosis. Thoracoplasty was not found to have any appreciable influence on the metabolic rate.

TABLE I

The arterial blood gases following thoracoplasty for pulmonary tuberculosis

Case	Date	Period after Thoraco- plasty	Oxygen				Carbon Dioxide			
			Capa- city vols. %	Con- tent	Satura- tion %	Capacity	Con- tent (serum) vols. %	Alveolar pCO ₂ Mm. of Hg.		
						at 40 Mm. pCO ₂ vols. %				
M. P.	10/ 3/33	Before op.	21.5	19.5	91 0	60.0	59.2	7.35	46.0	
M. P.	11/22/33	16 days	18.2	16.4	90		57			
J. M.	9/14/33	24 days	16 6	14.8	88 8	56.6	56 6	7.36	43 0	
L. A.	7/12/33	19 days	15 6	13.8	87 2	63.9	63.4	7.42	43.0	
W. S.	10/ 2/31	11 yrs.	16.4	13.2	80 2					
A. B.	12/21/32	36 days	18 6	16.6	88.9	67 5	61.9	7.40	44 0	
C. F.	2/ 3/33	2 yrs.	25 8	22.5	87.6	57.4	59.9	7.35	47.0	
A. A.	5/23/33	3 yrs.	21.1	19.3	91.3	51.7	52.1	7.37	40.0	
I. Q.	5/25/33	29 days	17.0	15.2	89.4	60 4	62.1	7.4	43.0	
L. L.	6/27/33	14 days	13.4	9.3	69 4	63.0	63.3	7.46	44.5	



GRAPH 5.—Pulmonary circulation rate in eight cases of pulmonary tuberculosis following thoracoplasty.

The Pulmonary Circulation.—The methods of measuring the cardiac output in man are still subject to so much error that the results obtained from a case with so impaired a respiratory function as results from thoracoplasty as well as tuberculosis would be of no value.

Observations were made on the pulmonary circulation rates in eight cases that were operated upon. A few cubic centimeters of Decholin (de-hydrocholic acid) when injected into the arm vein, can be tasted in the mouth at a relatively fixed period after the injection for a normal individual. This time varies from 10 to 13 seconds. The interval obviously measures more than the pulmonary circulation rate, since the material has to pass from the arm vein to the heart, and from the left ventricle to the taste buds of the tongue and the conscious recognition of that sensation. The number of observations is not great but the tendency to a delay in the circulation velocity is in each case definite. An adequate repetition of this simple test should prove of value (Graph 5).

Venous Pressure.—It has been frequently stated that the venous pressure is raised after phrenicotomy⁸ and pneumothorax.^{9, 10} Lately there has been published an article by Overholt and Pilcher¹¹ who find the venous pressure frequently raised after thoracoplasty. They consider it a guide in determining when to operate and how much rib resection to do without fear of a stormy postoperative period. They further consider a unilateral elevation of venous pressure a common finding. Our own observations of the venous pressure are not many and the readings have been in each case rather high normals than definite elevations above the normal.

One or two clinical observations might be mentioned that possibly have to do with the pulmonary circulation. It is frequently noticed that the uncollapsed lung, examined roentgenologically, takes on a more dense appearance following thoracoplasty. When this appearance is patchy, it is often thought to be a manifestation of an inflammatory process. In time these patches disappear without the patient going through the usual cycle of symptoms and signs that we associate with a spread in the disease.

Frequently, too, those patients that are subject to hemoptysis bleed after thoracoplasty and occasionally one encounters a tuberculous patient that has never had hemoptysis until after thoracoplasty. These two clinical observations, together with the delayed circulation velocity, are conclusive evidence that there is present in the lungs an extreme passive congestion.

Pulmonary Distensibility.—On three occasions a pneumothorax has been induced on the healthy side in patients that were to be operated upon for tuberculosis, even though there were no signs of active disease present. A small quantity of air was injected, 200 to 300 cc. sufficient to be seen roentgenographically and to insure that the pleural space was relatively free of adhesions. The usual negative readings were obtained. Following operation, however, when the patient was again placed in the same position as before operation and the pleural pressure again measured, the pressures

now fluctuated from the negative to the positive zone. This occurred in two instances, while in the third instance the pressure, on expiration, rose to zero. The extent of the fluctuation now likewise increased. In other words, more work was done in order to fill and empty the lungs with air. The tidal air must, if anything, have been diminished and such an increase in the pleural pressure fluctuation can mean only an increased pulmonary congestion comparable to what has been described in congestive heart failure.¹²

DISCUSSION.—One of the most obvious results of thoracoplasty in the early stages after operation is the extreme reduction in the total lung capacity and the functional residual air that appears altogether out of proportion to the extent of the rib resection. Even permitting of a small area of fibrotic disease in the contralateral lung, the impairment of lung capacity is greater than in those individuals that have only one functioning lung.

TABLE II

The lung volume and its subdivisions, etc., in a case of left-sided chronic pneumothorax, a case of complete bronchial stenosis of the left bronchus, and a case of total pneumonectomy of the left lung for carcinoma

	Y. M. Pneumothorax	A. M. Bronchial Occlusion	J. G. Pneumectomy
Total Capacity.....	1828	4122	2798
Functional Residual Air.....	984	2680	1725
Residual Air.....	898	2032	1364
Ratio $\frac{FRA}{TC}$	53.9	65.0	61.6
Respiration Rate.....	26.8	11.6	10.3
Tidal Air.....	148	504	430
Coefficient of Ventilation.....	5.5	4.74	4.86
Alveolar pCO ₂	42.0	39.0	44.0
Oxygen Saturation of Arterial Blood		90.3	94.8

Thoracoplasty frequently reduces the functional capacity of the lungs below that of an extreme collapse of each lung in bilateral pneumothorax. In case W.T., where the residual air and the functional residual air are reduced to 650 cc. and 750 cc. respectively, yet the ratio of the functional residual air to the total capacity is 40.7, a figure that lies within the range of the normal variation.

It has recently been ingeniously demonstrated by Bjorkman¹³ that not only is there remarkably little function in the diseased lung before operation, but also, after collapse, there is less. This he did by catheterizing each lung separately through a bronchoscope. His graphic tracings show conclusively the non-existence of pendulum air since there is no absolute paradoxical breathing.

At least some of the main reasons for a reduction of the lung capacity are to be found in the collapse of the chest wall, the paralysis of the diaphragm, weakness of the respiratory muscles and, in the early stages after operation, pain and paradoxical breathing. Yet with even these factors one would

not expect to see the total capacity of the lungs reduced by 50 per cent. Obviously there must be some other mechanism, such as pain, reflex inhibition of breathing or pulmonary congestion. The functional residual air would not, however, be diminished by pain or any other reflex action as would the total capacity.

It is not unnatural to find those factors that are vital to life remaining close to the normal limits, such as an adequate oxygen saturation of the arterial blood, a normal pressure of CO_2 in the blood and alveolar air and a normal coefficient of ventilation. The respiratory reserve, on the other hand, is greatly reduced and, in the case of L.L., practically eliminated. In this instance, the complementary air only differed from the tidal air by a few cubic centimeters, while the oxygen saturation of the arterial blood was 69 per cent. Bearing these factors in mind, the high mortality rate in the early stages of thoracoplasty, where 9, 10, and 11 ribs were removed at one operation, is not in the least surprising. Such a picture, too, should be seen by the mind's eye of the surgeon as he performs an extensive thoracoplasty.

A vast amount of experimental work has been done in pneumothorax to explain the circulatory readjustments. The oxygen saturation in the average pneumothorax case remains within normal limits; while in those patients upon whom arterial punctures were done after operation there was found quite a considerable reduction. This can be accounted for either by a diminution of aeration of the blood in the healthy lung, in the diseased lung, or both. The fact that the pulmonary circulation rate is at least temporarily decreased after thoracoplasty, added to the fact that the distensibility of the contralateral lung is diminished, are strong points of evidence in making clear the presence of a passive congestion in the uncollapsed lung.¹² The increased density of the radiographic shadow, the high normal or elevated venous pressure, and the occasional hemoptyses that possibly simulate those found in mitral stenosis, constitute additional evidence that points to the same conclusion. One would likewise expect an increase in the pulmonary second sound, a right heart hypertrophy and electrocardiographic changes, but of these factors we have not made a detailed study.

Unfortunately, we have little proof from this amount of data to show that the lung can, with time, regain a portion of the reserve it has lost. There is, however, an immense amount of clinical evidence to confirm these points.

We believe that the alteration in the respiratory rate and volume and dyspnea result from the decreased distensibility of the lung through the Hering-Brauer reflex, but it is not within the scope of this presentation to defend such a statement.

SUMMARY

In this study there have been measured the various subdivisions of the lung volume—the total capacity, the functional residual air and the residual air—before and after thoracoplasty. Within a short period of the opera-

tion, these values tend to become greatly reduced, and their absolute measure in any given case must serve as a guide to the surgeon when contemplating further collapse. The ratio of the functional residual air to the total capacity in this connection is emphasized. The reductions in total capacity and functional residual air are greater in most cases than can be attributed to the operation alone. This can be explained largely by the change in the pulmonary circulation which, for a time, shows a lessened velocity. The distensibility of the uncollapsed lung is diminished, the intrapleural pressure being altered to simulate that found in circulatory failure.

The increased density in the radiogram of the contralateral lung, the high normal or elevated venous pressure, the diminished oxygen saturation of the arterial blood and the occasional hemoptyses that follow operation, all seem to indicate that the reduction in lung capacity after operative collapse is due largely to a passive venous congestion.

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DISCUSSION.—DR. EDWARD D. CHURCHILL (Boston, Mass.).—Doctor McIntosh has presented an exacting and quantitative study concerning certain functions of the lung. I am sorry that his manuscript was not available for study before his presentation as it is impossible to make any intelligent comment on the data without more deliberate consideration.

The general significance of such studies is quite apparent, however. Advances in thoracic surgery have now made possible the successful removal

of one entire lung. More exact determination of function is now essential as in other situations where a surgeon takes the responsibility of removing one member of a paired organ.

Determinations of vital capacity are very limited in their value. Determination of the actual volume of the lungs is a step in advance, as also is the study of residual air in relation to total lung volume. What is greatly desired at the moment is a simple method of determining what may be called the "split" function of the lung or the assessment of the separate functions of the right and left lungs, respectively.

As the rôle of surgery in pulmonary tuberculosis has been extended to include frankly bilateral cases, it becomes important to gain a clear concept of the ability of a partially diseased lung to meet the needs of the body. In the application of total pneumonectomy to malignant disease we are faced with an age group of patients that are notoriously poor risks for radical thoracic operations. Many have emphysema or other cardiorespiratory changes associated with advancing age, and it seems imperative to test the function of the lung that is to remain before removing the one that contains the cancer.

The best method available at the moment is to collapse the lung that is to be removed by artificial pneumothorax, but this is not always possible. Even a total pneumothorax on one side does not reproduce the state of affairs that follows the surgical extirpation of one lung.

Efforts are being made in the clinic of Professor Jacobeus in Stockholm to determine the function of each lung separately by means of a cannula inserted directly into one primary bronchus. This method combined with the careful methods of study used by Dr. McIntosh may point the way to the desired goal.

SURGERY FOR CERVICAL RIBS [†]

RUSSEL H. PATTERSON, M.D.

NEW YORK

CASE REPORTS

CASE I.—Miss U. W., 24 years of age, a typist, referred by Dr. P. E. Sabatelle, June 15, 1934.

Present Illness.—As a child she had had occasional pain in her left arm and, for many years, occasional cramps in her left hand which had grown weak during the past two years. Two months before examination these symptoms increased, with the addition of pain around the left wrist and left thumb and on the left side of her neck, sometimes radiating down the left side of her body. At times there seemed to be some numbness in the left thumb on the palmar aspect. She stopped her work as a typist for a few weeks and the pain in her left arm disappeared, but not the pain in her neck. As soon as she resumed typing, the pain in her left hand recurred.

Physical Examination.—The patient was a very small woman, weighing 97½ pounds, healthy in appearance and well nourished. In the posterior triangle of the left side of the neck at about the middle of and above the clavicle there was a definite bony prominence and general fulness which was not present on the right side of the neck. Pressure over this area was painful, locally. There was no disturbance in sensation of the entire left upper extremity. The grip in the left hand was noticeably weak and there was a moderate amount of atrophy of the thenar eminence of the left hand. Roentgen examination showed cervical ribs on both sides articulating with the first ribs (Fig. 1).

Operation.—June 20, 1934, at the Hospital for Ruptured and Crippled, the patient was operated upon under gas-oxygen anesthesia. An oblique incision was made in the left side of the neck, one and one-half inches lateral to the attachment of the sternocleidomastoid muscle just above the clavicle, as suggested by Dr. Alfred S. Taylor. The fascia over the brachial plexus was exposed and divided. The brachial plexus, the scalene muscles and the subclavian artery were exposed. The brachial plexus was found pinched between the cervical rib and the middle scalenus muscle on one side and the anterior scalenus muscle on the other side. The cervical rib was partly covered by the scalenus medius muscle. There was a definite articular facet on the first rib for the end of the cervical rib. The scalenus medius muscle was divided at the junction of its middle and lower thirds. The cut end of the lower third was clamped and pulled forward against the brachial plexus. This served as an excellent retractor for the plexus. The entire cervical rib was removed with rongeurs. The transverse process of the seventh cervical vertebra was not disturbed. The brachial plexus and subclavian artery then fell back into the space occupied by the cervical rib. The anterior scalenus muscle was then divided and the wound closed.

July 3, 1934, 13 days after operation, the patient had no symptoms in her left hand but there was a slight anesthesia over the left shoulder. July 27, 1934, the blood pressure in the left arm was 116/65, in the right arm 109/65. There were no changes in the blood pressure before operation. There was diminution of skin sensation over the shoulder lateral to the scar of operation. October 15, 1934, the patient was symptomatically relieved, having no complaints whatever. Her grip was good and the extremity appeared normal.

CASE II.—Miss M. D., age 22, a dictaphone operator, referred by Dr. H. H. Fel-

[†] Presented before the New York Surgical Society, February 27, 1935.

SURGERY FOR CERVICAL RIBS

lows, examined October 27, 1932. Except for tonsillectomy one year ago her past history is negative.

Present Illness.—Although the patient thought her left arm had “always been funny,” symptoms in this extremity were not especially noticeable until two years previously when she began to experience pain in the front part of the left shoulder and left side of the neck, the pain jumping to the back of the left forearm. She had no pain whatever in the left upper arm, but whenever she slept on her left shoulder she would awaken from the pain. This would disappear when she turned over. More recently, the attacks of pain were associated with sore throat. The grip in her left hand she



FIG. 1.—Preoperative roentgenogram of Case I. The cervical rib is shown as a direct shadow running from the seventh cervical transverse process down to and articulating with the rib just above the shadow of the clavicle.

thought was not impaired but she would experience a tingling of the third, fourth and fifth fingers of the left hand and at times the outer three fingers grew numb as she typed.

Physical Examination.—The patient is a healthy appearing girl, weighing 116 pounds, with round shoulders and normal reflexes. There was a fulness on both sides of the base of the neck, but particularly on the left, extending over an area several inches in diameter and lying roughly above the outer end of the left clavicle and in front of the anterior border of the trapezius muscle. The swollen area was firm and painful on deep palpation. There was no atrophy of the left upper extremity and no disturbance of skin sensation. Both pulses were equal. Roentgen examination showed a cervical

rib on the left side articulating with the first rib. There was also a rudimentary cervical rib on the right side (Fig. 2).

Operation.—November 15, 1932, at the Hospital for Ruptured and Crippled, under gas-oxygen anesthesia an incision was made similar to the one described in Case I. The cervical rib articulated with the first rib at the attachment of the middle scalenus muscle. The lower third of the middle scalenus muscle was divided and the distal end grasped with a clamp and used as a retractor for the brachial plexus. The rib was then removed with a rongeur and afterwards the brachial plexus and subclavian artery dropped back into the place formerly occupied by the rib. Attempt to remove



FIG. 2.—Preoperative roentgenogram, showing cervical rib in Case II as a direct shadow running from the seventh cervical transverse process down to and articulating with the rib just above the shadow of the clavicle.

the rib in one piece is dangerous. The anterior scalenus was then divided at its attachment with the first rib so that there could be no question of pressure on the brachial plexus.

Follow Up.—For several weeks, the patient had some pain in the region of the ulnar nerve distribution, due probably to too much retraction on, and handling of, the brachial plexus. Extreme gentleness is necessary in this operation. The skin over the left side of the neck was very hypersensitive. There was no atrophy in the left hand or left arm and no limitation of motion in any joint. She claimed to feel a "pulling sometimes in the left side of the neck." April 28, 1933, the patient had returned to her usual work and was free of all symptoms.

SURGERY FOR CERVICAL RIBS

CASE III.—Mrs. A. M., 28 years of age, housewife, referred April 16, 1935, by Dr. J. Sullivan and Dr. H. C. W. S. deBrun.

Present Illness.—About six months ago patient began to have marked pain and numbness in her left upper extremity. A week or two later she noticed lumps on the left side of her neck, the inner side of her left upper arm, the inside of the left elbow and the left wrist. The left hand has become thin, weak and is always as cold as ice. Numbness of the whole extremity bothers her the most. She has peculiar tingling pain in the index, middle and ring fingers.

Physical Examination.—Chubby, small, overweight Irish woman. There was slight swelling at the base of the left side of the neck. The upper arms were each $10\frac{3}{4}$ inches in circumference. The left wrist was one-quarter of an inch smaller than the right which measured $6\frac{1}{4}$ inches. The left hand is a little thinner than the right. There may be slight atrophy of the intrinsic muscles of the left hand but particularly of the thenar and hypothenar eminences. The pulse in the left wrist cannot be felt. Axillary



FIG. 3.—Roentgenogram of Case III. Showing cervical rib from a lateral view of the chest. The rib may be seen at the top of barium which was just passing through the esophagus.

pulse on the right can be felt but not on the left. Blood pressure right arm 120/80. Left—no blood pressure can be obtained. She has diminished tactile sensation on the dorsum of the third and fourth fingers of the left hand. The skin of the palm and dorsum of the hand is hypersensitive. When she stands up there is distinct fulness in the left side of the neck. Pressure over this fulness causes her local pain. Twisting her head to the left is painful. Roentgen examination showed cervical ribs on both sides articulating with the first ribs (Fig. 3). The lateral views of the cervical region were particularly interesting in that they showed the full length of the cervical rib in a view not commonly seen.

Operation.—April 17, 1935, at the Hospital for Ruptured and Crippled the patient was operated upon under gas-oxygen anesthesia. An oblique incision was made in the left side of the neck similar to Cases I and II. The anterior scalenus muscle was identified and found to be $1\frac{1}{2}$ inches or more in diameter, being greatly hypertrophied. The cervical rib was deep and articulated with a definite facet at a point on the first rib corresponding to the interval between the scalenus medius and scalenus anticus muscles. The brachial plexus was very deep and was a so called postfixed type (Fig. 4). In other words, it came off one segment lower than normal. The subclavian artery came up distinctly over the cervical rib very near the articular facet on the first rib.

The artery was angulated. It consisted of a thick fibrous cord the size of an ordinary pencil. Its walls could not be compressed. There was no blood in it as was shown by the fact that a hypodermic needle was introduced at intervals and no blood obtained. It would have been interesting to inspect the artery for a greater part of its course, but this was not practical because serious interference with collateral circulation might have resulted. The anterior scalenus muscle was completely divided near its rib attachment. The scalenus medius muscle was divided. The cervical rib was removed from its attachment to the first rib back to within $\frac{1}{2}$ inch of the pedicle and the wound then closed.

May 15, 1935, four weeks following operation, the patient noted that the increased warmth in the left upper extremity, which had been noted immediately after the operation, still persisted. The extremity did not feel so numb and there was none of the old pain that the patient had previously felt. However, there were times, particularly at night, that a different type of pain was experienced through the shoulder and ex-

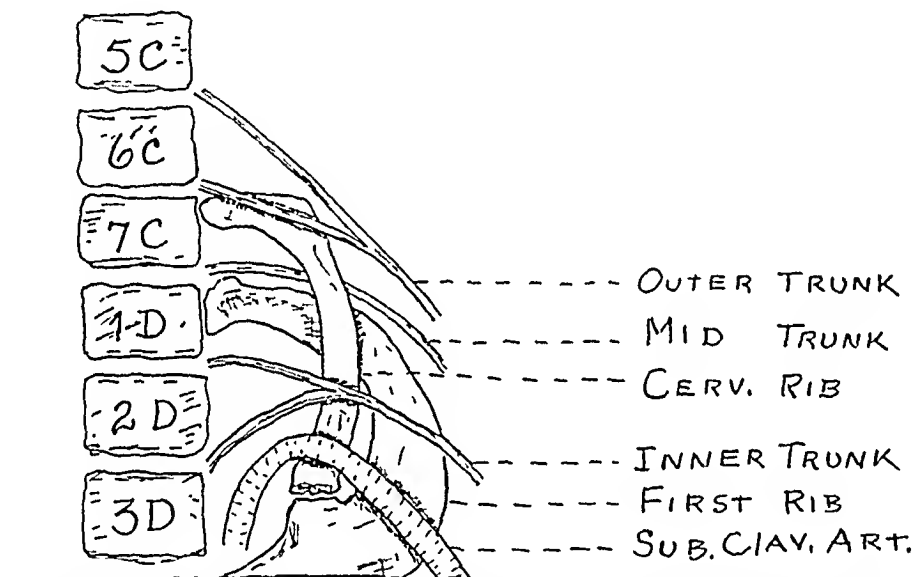


FIG. 4.—Diagram of Case III, illustrating the postfixed brachial plexus and its relation to the cervical rib. Also the relationship of the subclavian artery to the cervical rib.

tremity. This was interpreted as being due to the handling of the brachial plexus at operation. Postoperative roentgenograms showed the left cervical rib to have been removed.

COMMENT

(1) Cervical ribs giving symptoms are not common in the average surgical practice.

(2) The use of the distal end of the divided scalenus medius muscle as a retractor for the brachial plexus is a helpful maneuver in the removal of a cervical rib.

(3) Reviewing the anatomy of the neck, Piersol makes the following points: There may be a slight outward projection from the ventral side of the cervical vertebral body representing the prominence for the head of the rib to rest upon; there may be a hooklike growth of bone from the tip of the transverse process; a cervical rib may develop from a separate center of ossification anterior to these two bony variations; and these may all grow

in such a manner as to form a transverse foramen and a cervical rib. The cervical rib may run forward parallel to the first rib sometimes reaching half way to the sternum and sometimes articulating with the first rib. Occasionally a process grows up from the first rib to meet the cervical rib. This process may raise or markedly encroach upon the subclavian artery.

Furthermore, there may be a variation in the scalene muscles. Their origins may be increased or diminished; fusion may occur; the scalenus anticus may be perforated by the subclavian artery and the portion of the muscle so separated may form a distinct muscle, the scalenus minimus. This muscle may attach itself to the upper surface of the first rib and to the dome of the pleura.

A great many of the fibrous bands, described by various surgeons as encroaching upon the brachial plexus, would be better understood were all these anatomic variations appreciated. Because of these variations I do not believe we can set down a single procedure which, when carried out, will relieve every case of so called cervical rib. Simple division of the scalenus anticus has been advocated by some as being the operation of choice for all so called surgical ribs. I believe we must deal with variations as we find them at the time of the operation. Furthermore, symptoms will vary according to the variations in the anatomy.

(4) I have seen three other cases of well marked cervical ribs in the last year. None gave symptoms. One case was in a nurse, one in a patient with a severe pulmonary infection, and one in a girl with an adenoma of the thyroid.

(5) Most of these cases are in working girls who do not have symptoms until over 20 years of age.

(6) Why the symptoms nearly always occur on the left side, even though the cervical ribs are bilateral, I do not believe is known.

(7) Case III seems to be quite unusual, a report of Cushing's being the only other instance in which an obliteration of the artery has been described.

(8) Roentgenograms taken in the lateral position, as shown in Fig. 3, are very instructive and have in the past not been routinely taken.

DISCUSSION: DR. DE WITT STETTEN (New York) said that cervical rib cases might be divided into two classes, those producing nerve symptoms and those producing arterial symptoms. Although the vascular cases constitute the minority, they are very interesting, as illustrated by a case recently treated. The patient was a telephone operator with a cervical rib, not on the left, but on the right side. The symptoms were entirely vascular, a typical Raynaud's syndrome developing in the hand, especially when it became cold. Under ordinary conditions there was not much difference in the pulse, but if the arm were pulled on the long axis of the body and the head turned sharply to the opposite side, stretching the scalenus muscle, the pulse could be obliterated (Halsted test). At operation, as the scalenus anticus was divided, the artery—which was acutely kinked by the tense muscle—completely relaxed and straightened out. In spite of this, and the fact that division of the scalenus anticus would probably have been sufficient, Doctor

Stetten resected the larger portion of the cervical rib which articulated with the first rib.

Particular attention should be called to a possible difficulty not mentioned by Doctor Patterson, that is, the case with which the pleura may be punctured during resection of a cervical rib. In the case cited above this accident occurred even though the possibility was borne in mind and the greatest precautions taken to prevent it. Opening of the pleura rarely occurs in upper thoracoplasties, but, of course, this operation is usually done in tuberculous cases with a thickened pleura, and often with obliterated pleural cavities, so that the danger is very slight. In cervical rib cases, however, there appears to be a long tongue of extremely thin pleura that comes right up to the periosteum of the rib. In this instance the periosteum had been completely separated from the rib and he was about to resect the rib with a costotome when the tip of the instrument, which was not quite adapted for his particular purpose, made a small hole in the pleura. Suture was attempted but, owing to the thinness of the tissue, was found to be impracticable. Influx was controlled readily by a tamponade. There was no unfavorable result except the necessity for drainage and a slight postoperative rise of temperature with an insignificant pleural exudate which was absorbed. The patient's symptoms were completely relieved by the operation and the Halsted test became negative.

DR. IRA COHEN (New York) drew attention to the fact that in connection with vascular symptoms, in addition to actual pressure there is an element of spasm, well illustrated in the case of a nurse with a cervical rib whom he treated in 1933. In this patient, without any change of posture, the radial pulse would disappear, only shortly afterwards to reappear and then disappear again. The appearance of the hand resembled that of Raynaud's disease. Division of the scalenus muscle alone relieved the symptoms.

DR. JOHN M. HANFORD (New York) described the case of a colored woman, aged 28, at present in Presbyterian Hospital, with a cervical rib on the right side instead of on the left where it usually occurs. The patient came in because of weakness, dyspnea, palpitation, and pain in the right upper limb. In the Medical Ward, she was found to be running a low grade fever, the cause of which had not been determined. Her basal metabolism and Wassermann tests were negative, the blood pressure normal. On examination, there was an enlarged heart, rapid pulse and dilatation of the subclavian artery just beyond the rib, which may be indirectly the causation of the circulatory findings. The rib is evidently constricting the artery which is dilated beyond the constriction, measuring 2 cm. at least, and is much larger than that on the left side. It gives a bruit and a definitely pulsating expansion is visible and easily palpable.

Apparently the local symptoms in this case are due more to pressure on the subclavian artery than on the nerve plexus. The patient does not appear to have symptoms corresponding to pressure on the ulnar nerve or on the median cord of the plexus. She does have some weakness of the hand and some paresthesia of the upper limb. The constriction of the artery by the cervical rib may be causing a terrific impact on the wall of the artery just beyond, gradually weakening it over a period of years. Another theory is that nutrition of the artery just beyond the constriction is such as to weaken it. Actually, the patient now presents the picture of a small aneurysm which may easily interfere with the operation which the patient certainly should have to release the pressure.

DR. BYRON STOOKEY (New York) felt that it would be futile to attempt to classify cervical ribs into groups in view of the wide variations. There may be a cervical rib varying from a very small nubbin to a complete bony rib, which articulates behind with the vertebra and in front with the first rib, or, in place of articulating, fuses with the vertebra, with the first rib, or with both, thus presenting a solid bony structure. Important to remember, too, is the fact that instead of a bony rib, a small fibrous band may continue forward from a very small transverse process to the first rib in front and compress the plexus as though it were a solid rib. Although this fibrous band does not show in the roentgenogram, it may nevertheless give rise to the same symptoms as an actual bony protuberance.

Cervical ribs appear most commonly in the presence of a prefixed plexus, that is, a plexus which has arisen a segment or two higher than is considered normal, the normal—if normal there be—being really a mean between a prefixed and a postfixed plexus. The variation in the position of the plexus depends upon the position of the developing limb bud. It is the relative position of the plexus to the developing cervical costal structures which determines whether or not a cervical rib will form, since the outgrowing nerve bundles cut off the mesodermal costal structure which would normally develop a cervical rib were it not for the traction of the outgrowing nerve bundles across the developing costal structures. In the lower forms where extremities do not exist and hence no limb bud or outgrowing nerve bundles, cervical and lumbar ribs are the rule. The only reason cervical and lumbar ribs are not present is due to the developing limb bud and the nerve structures which grow out to reach the limb bud.

Among the reasons given for the development of symptoms in the second, third and often as late as the fourth decade is the fact that ossification in later life destroys the resilience which is found in younger individuals. Moreover, in adult life there is a further descent of the shoulder which puts greater stress on the plexus itself as it passes over a cervical rib. However, in Doctor Stookey's opinion, the most likely explanation is the same mechanism which produces ulnar nerve palsies 20 or 30 years after fracture of the internal condyle of the humerus. Under these circumstances the ulnar nerve is subjected to continuous trauma with each extension and flexion of the forearm due to the faulty angle of the internal condyle which makes the ulnar nerve cross the condyle at an acute angle. Similarly, by each inspiration and expiration the rise and fall of the thorax causes pressure upon the brachial plexus as it passes out of the thorax over a cervical rib. This continuous trauma eventually injures the nerves just as the sharp angle of a fractured internal condyle of the humerus injures the ulnar nerve, and symptoms occur.

Doctor Patterson's point of using the scalenus muscle as a retractor to pull the brachial plexus forward Doctor Stookey regarded as excellent, since trauma to the plexus is very likely to occur unless great care is used to avoid traction upon the nerve roots.

POSTERIOR DRAINAGE IN SUPPURATIVE PERICARDITIS

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CASES of acute suppurative pericarditis are not common and the diagnosis and treatment of this condition have always been of great interest to both physicians and surgeons. The opportunity was recently afforded to care for a patient who presented the typical signs of increased intrapericardial pressure and who recovered in due time after the institution of drainage and repeated irrigations of the pericardial cavity. In this instance, at the suggestion of Dr. Hugh Auchincloss, the pericardial sac was opened posterolaterally in its dependent part and it was the impression of those who followed the course of the patient after operation that recovery was due in large measure to the satisfactory drainage which was provided by this incision. When this patient came under my care I was not familiar with the paper which was recently published by Truesdale¹ in which he advocated drainage through an incision similar to the one which I used. He apparently also appreciated the difficulty of maintaining adequate drainage through the anterior (parasternal) route, and when the situation became desperate in his case, decided to supplement the anterior incision with a posterior one, accepting the risk of opening and infecting the pleural space for the advantages of dependent drainage. He found the base of the left lung adherent to the pericardium and was able to strip it away and expose the posterolateral wall of the pericardium without entering a free pleural cavity. The presence of adhesions minimized the possibility of a complicating empyema, but regardless of what the outcome would have been if the latter complication had arisen, the patient made a satisfactory recovery.

Adhesions were present in my case also, making it similar to that reported by Truesdale. Drainage of the pericardium posteriorly was felt to be so important that the decision was made to enter the pleura (if need be) in order to accomplish it, and accept the risk of a pneumothorax and another empyema. Fortunately, the adhesions made it possible to expose the posterolateral wall of the pericardium without this complication occurring.

CASE REPORT

History and Physical Examination.—A Jewish boy, aged 12, was referred by Dr. M. R. Bradner of Warwick, N. Y., June 3, 1934. His illness dated from the latter part of February, when he developed a pneumonia of the left lung. Temperature remained elevated for seven days and then dropped rather abruptly to slightly above normal. After this his convalescence was complicated, first by marked distention of the abdomen, which persisted for one week; then by an abscess of the left middle ear, which necessitated drainage; and finally by a suppurative pleurisy on the left side

posteriorly. The organism was not determined. The left pleural cavity was drained on April 2 by resecting a segment of the eighth rib, following which the patient improved. At the end of the second week he was up and walking when suddenly his temperature rose to 105°. The fever persisted, running an irregular course, and on May 7 a piece of the ninth rib was resected in order to provide more adequate drainage for the empyema cavity. The boy's condition was never satisfactory after this. The wound continued to drain, temperature remained elevated and there were repeated spells of nausea. May 22 the wound was explored with a small rubber catheter and radiographs of the chest were made after the injection of lipiodol. These demonstrated a sinus tract which extended through the chest wall for a distance of about 2½ inches, but no cavity. The sinus tract was irrigated frequently with Dakin's solution during the next three days and the boy seemed to improve again. Then his temperature became very high and another radiograph of the chest showed a distended pericardium. The pericardial sac was aspirated through the fourth intercostal space and 60 cc. of thin, turbid fluid were recovered. Smear and culture were not made. The boy did not show any tendency to improve and on June 3 he was transferred to the Presbyterian Hospital.

The following observations were made during the three days preceding operation: The boy was pale and weak, but in a surprisingly good state of nutrition considering the duration and nature of his illness (Fig. 1). There was no cyanosis and no edema. Respirations were rapid and shallow with expiratory grunt and pronounced retraction of the lower intercostal spaces anteriorly on both sides. Temperature fluctuated between 100.8° and 104.6°. The veins in the neck were distended, but not greatly dilated and not tortuous. The superficial veins over the anterior chest wall, abdomen and upper extremities were plainly visible and dilated, but could not be felt. The right chest was clear. The left chest showed dullness and diminished breath sounds posteriorly in the region of the operative scar. A cardiac impulse could neither be seen nor felt. The left border of cardiac dullness was 4 cm. to the left of the midsternal line in the first interspace, 5.5 cm. to the left in the second, 10 cm. in the third and 11 cm. to the left in the fourth and fifth. The right border of cardiac dullness also was 4 cm. from the midsternal line in the first interspace, 5.5 cm. in the second, 6.5 cm. in the third and fourth, and 6 cm. in the fifth. Heart sounds were faint. The measurements of the heart as obtained from a two meter heart film were reported as follows: MR 6.7; ML 9.0; TD 15.7 and GV 7.8; internal diameter of the chest 22.5. The area of cardiopericardial density was described as having a "water-bottle" shape (Fig. 2).

A fluoroscopic examination did not reveal any cardiac pulsations on either side. An electrocardiogram showed elevation of the RT interval in the first and second leads and inversion of the T waves in the first lead. There was a marked pulsus paradoxus, and the pulse, which varied between 110 and 140, could not be accurately obtained at the wrist. The arterial pressure was not recorded. The venous pressure, as obtained by the direct method of Moritz and von Tabora² was 240 cm. of physiologic salt solution. The abdomen was prominent and gave a fluid wave. The liver was enlarged and tender, its edge palpable 8 cm. below the costal margin in the midsternal and midclavicular lines. Red blood cells were 3,800,000; hemoglobin, 53 per cent; white blood cells, 14,400; polymorphonuclear leukocytes, 85 per cent. The urine was negative except for a faint trace of albumin.

June 4 the pericardial sac was aspirated again through the fourth intercostal space. The needle was introduced 1 cm. within the line of the nipple and 90 cc. of thin, light green, turbid fluid were withdrawn. When this amount had been obtained the aspiration was discontinued because the fluid became blood tinged and the pulsations of the heart were being transmitted to the shaft of the needle. The venous pressure was measured repeatedly while the fluid was being withdrawn. After the withdrawal of 6 cc. it was 210 cm. of physiologic salt solution. When 20 cc. had been withdrawn



FIG 1.—Photograph of patient taken June 5, the day of operation. The crosses mark the sites of the two aspirations.



FIG. 2.—Roentgenogram taken June 4. 90 cc. of light green turbid fluid were withdrawn from the pericardium shortly after this film was made and at operation on the following day an additional 500 cc. were obtained. The empyema cavity was closed at this time, but a drainage tube was still present in the sinus tract that remained. This tube can be seen very distinctly in the picture.

it had dropped to 165 and subsequently the measurements were 155, 145, 135, 125, and 115; after the withdrawal of 40, 60, 70, 80 and 90 cc., respectively. A culture of the fluid showed hemolytic streptococci. Specific gravity was 1.020 and the cell count was 19,000.

Operation.—Operation was performed under colonic ether anesthesia June 5. The left lung was adherent to the chest wall, diaphragm and pericardium, permitting the pericardium to be exposed without opening the free pleural space. The adhesions were delicate and were easily separated without bleeding of any consequence. The exposed surface of the pericardium bulged into the wound. When it was opened the exudate within spurted through the incision. The amount of exudate was not measured, but it was estimated to be at least 500 cc. The exudate was turbid, thin, light green, and contained clumps of fibrin. The surface of the heart was covered with a shaggy fibrinous exudate. After the heart was decompressed the boy breathed more easily and the volume of the pulse improved.

Operative Procedure.—Patient in a reclining position, turned slightly to the right side so as to permit access to the left axilla.

A double curved incision was made over the fifth intercostal space, extending from the lateral end of the sixth costal cartilage to the posterior fold of the axilla (Fig. 3). The two flaps thus made were reflected upward and downward to expose the surfaces of the fifth and sixth ribs. Access to the thorax was gained by resecting subperiosteally segments of the anterior ends of the fifth and sixth ribs, each approximately four inches in length. In front the ribs were divided just lateral to the costochondral junctions. The intercostal muscles, together with the intercostal fascia, were stripped away from the parietal pleura and the vessels ligated both anteriorly and posteriorly. The pleura was incised through the bed of the sixth rib and the adherent part of the lung dissected off the diaphragm and pericardium. This gave an excellent exposure of the pericardium posterolaterally. The pericardium was opened through a horizontal incision approximately three inches long, the exudate evacuated and pressure-maintenance drainage established with a specially constructed tube (Fig. 4).*

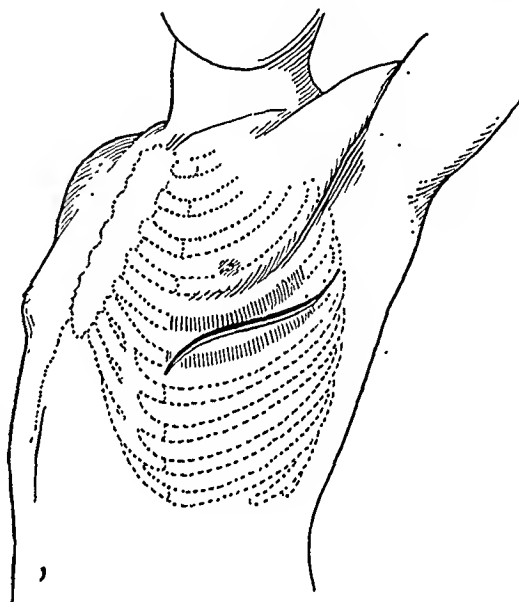


FIG. 3.—Diagrammatic sketch showing the position of the incision that was made in the case reported. The shaded parts of the fifth and sixth ribs were resected.

The tube was anchored snugly in place with vaseline gauze, supported with additional dressings of dry gauze and fixed to the chest with strips of broad adhesive. The boy left the operating room in good condition. However, there was a slight suggestion of cyanosis and for this reason the administration of oxygen in a tent was begun immediately.

* It is not felt that the use of closed drainage in this particular case was essential, because the free pleura was not opened. The author believes that open drainage would have been equally as effective. The use of two large rubber tubes would have provided more adequate drainage and in another similar case it is planned to use two tubes, passing them through the apex of a silk and gauze tampon down to, but not through the opening in the pericardium. The tampon would serve to hold back the edges of the wound and the lung, causing them to be molded apart. In this manner, after six or seven days a spacious tract would be established and the tubes and tampon could be discarded.

In consideration of the experiments of Beck and Isaac³ there is reason to believe

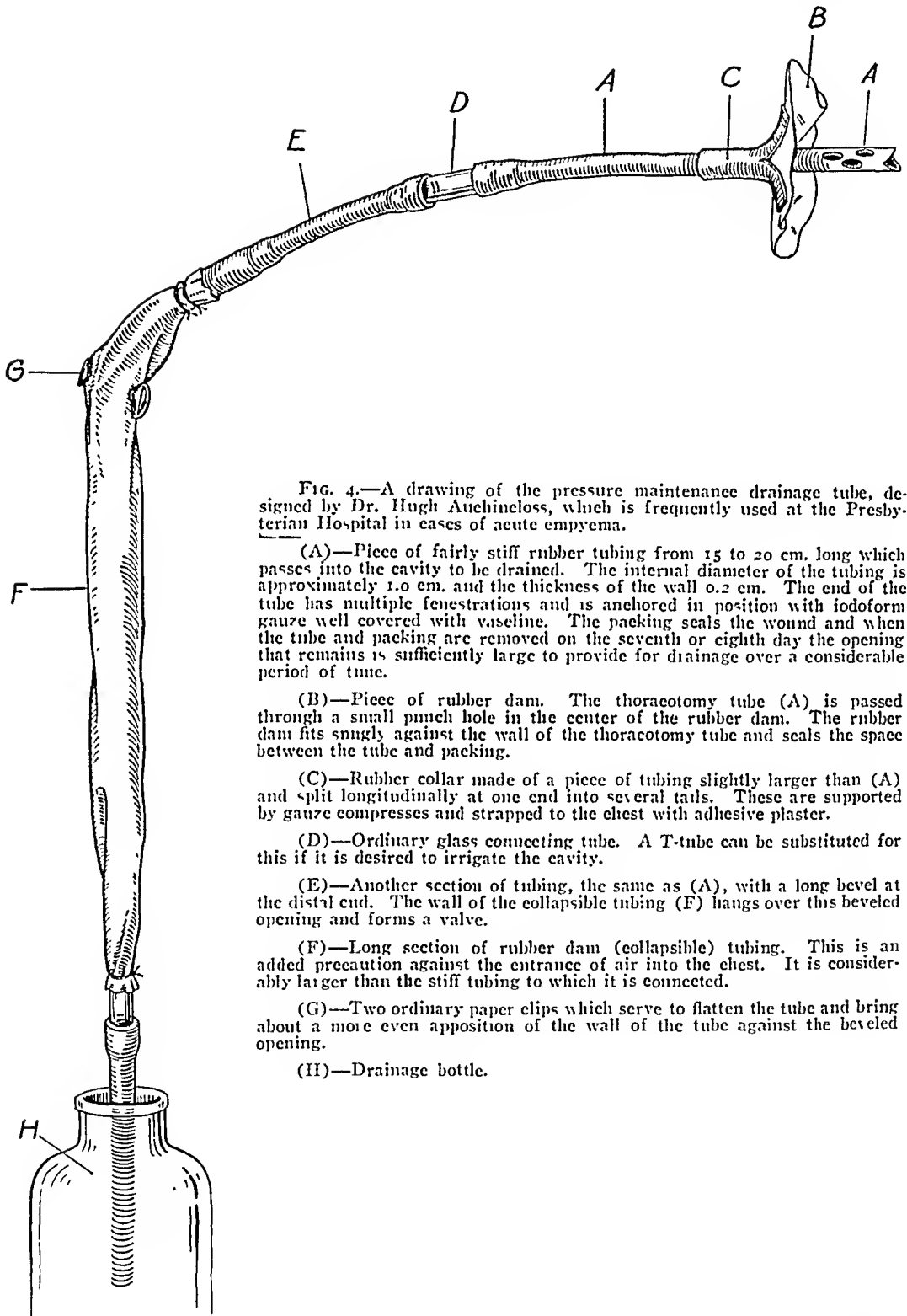


FIG. 4.—A drawing of the pressure maintenance drainage tube, designed by Dr. Hugh Auchincloss, which is frequently used at the Presbyterian Hospital in cases of acute empyema.

(A)—Piece of fairly stiff rubber tubing from 15 to 20 cm. long which passes into the cavity to be drained. The internal diameter of the tubing is approximately 1.0 cm. and the thickness of the wall 0.2 cm. The end of the tube has multiple fenestrations and is anchored in position with iodoform gauze well covered with vaseline. The packing seals the wound and when the tube and packing are removed on the seventh or eighth day the opening that remains is sufficiently large to provide for drainage over a considerable period of time.

(B)—Piece of rubber dam. The thoracotomy tube (A) is passed through a small punch hole in the center of the rubber dam. The rubber dam fits snugly against the wall of the thoracotomy tube and seals the space between the tube and packing.

(C)—Rubber collar made of a piece of tubing slightly larger than (A) and split longitudinally at one end into several tails. These are supported by gauze compresses and strapped to the chest with adhesive plaster.

(D)—Ordinary glass connecting tube. A T-tube can be substituted for this if it is desired to irrigate the cavity.

(E)—Another section of tubing, the same as (A), with a long bevel at the distal end. The wall of the collapsible tubing (F) hangs over this beveled opening and forms a valve.

(F)—Long section of rubber dam (collapsible) tubing. This is an added precaution against the entrance of air into the chest. It is considerably larger than the stiff tubing to which it is connected.

(G)—Two ordinary paper clips which serve to flatten the tube and bring about a more even apposition of the wall of the tube against the beveled opening.

(H)—Drainage bottle.

that the filling of the heart is supported by subatmospheric pressure. After rib resection, however, it is not practical to maintain an airtight seal for more than six to eight days. Since drainage in suppurative pericarditis must be provided for a much longer period than this, and since irrigations are so important, closed drainage is probably not necessary unless the free pleura is opened and then only long enough to permit the formation of adhesions.

Postoperative Course.—The patient was kept in the oxygen tent until June 20 during which period he continued seriously ill with a high fever (102° to 104°), rapid, weak paradoxical pulse and rapid, irregular and shallow breathing. June 7 the red blood cells were 2,520,000; hemoglobin, 75 per cent; white blood cells, 18,200; polymorphonuclear leukocytes, 71 per cent. Blood culture was negative June 8. A transfusion of 500 cc. of whole blood was given on this date. The immediate reaction to this was alarming. Respirations rose to 60; there was profuse diaphoresis; skin became cold and cyanotic; and pulse almost imperceptible. The boy was listless, unresponsive and had an involuntary defecation. Fortunately he recovered from this reaction within an hour. The drainage tube functioned perfectly and from the time of operation up to the afternoon of June 12, 1,600 cc. of purulent material were evacuated. At this time the dressing had become saturated with pus, and pus was dissecting the adhesive strapping from the skin. Consequently the tube and all the packing were removed and after this the wound was left wide open. The tract which led down to the pericardium was spacious. The heart could be seen through the opening which had been made and a considerable amount of fibrinous exudate was still attached to it. Pus was puddling in the depth of the wound. After irrigating the wound with warm saline, it was dressed with a silk and gauze tampon with a piece of rubber dam passing through the apex of the tampon just to, or perhaps a little way through, the pericardial opening. The wound was irrigated and dressed in a similar manner every day, Dakin's solution being substituted for saline June 15. At first there was no decrease in the amount of discharge, and June 18 a rubber catheter was passed posteriorly to the heart into the oblique sinus (culdesac) and 8 cc. of residual exudate were evacuated. This was repeated with similar results once a day during the next five days and June 23 two Carrel tubes, a long one, through which the cavity was irrigated, and a short one to provide for reflux, were inserted and left in place. After this, instillations of Dakin's fluid were given at frequent intervals until July 9. During this time the wound was dressed daily and at each dressing, after removing the Carrel tubes, the pericardium was irrigated with a pint of Dakin's solution through a catheter.

The purulent discharge cleared up rapidly under this treatment and within a few days the boy began to show definite signs of improvement. Whereas he had been irritable and fretful up to this time, now he became pleasant and cooperative. His appetite increased; the temperature approached a lower level; and the white blood cells which had been 29,000 on June 25, with a polymorphonuclear percentage of 98, had dropped to 16,000 on June 30, with a polymorphonuclear percentage of only 79. July 5, 725 cc. of thin, sterile fluid were aspirated from the right chest. The boy was sitting up for a few minutes each day at this time. He began to walk July 14 and temperature reached normal July 17. Irrigations of the pericardial cavity with physiologic salt solution (which had been resumed July 9 when the instillations of Dakin's solution were discontinued) were stopped July 25. The sinus tract closed July 30 and the boy was discharged from the hospital August 3. At the time of discharge he weighed 80 pounds and was gaining weight rapidly; the veins in his neck were no longer distended; the superficial veins of the trunk and abdomen were much less prominent than they had been; there were no signs of pleural fluid; the liver edge could not be felt; and there was no ascites. The venous pressure June 30 was 88 cm. of physiologic salt solution. The pulse, which had remained rapid and paradoxical until the latter part of July, had slowed to 90 and assumed a normal quality.

Follow Up Observations.—The boy continued to improve after discharge from the hospital. He rapidly regained his strength and in two weeks' time gained nine pounds. When seen August 17 he appeared to be in excellent physical condition. The pulse was slow, regular and of good quality. There were no signs of fluid, either in the chest or abdomen. The veins in his neck were not distended and the liver could not

be felt. He was seen again October 8 (approximately four months after operation) at which time he weighed 106 pounds, was active at school and symptom free.

DISCUSSION

I do not believe that the recovery in this case is to be attributed solely to the site which was elected for drainage. Such a claim would be open to question because the case was a favorable one in several respects. When the boy came under my care he had recovered completely from his pneumonia, the empyema cavity was closed and the general state of his nutrition was good. Furthermore, after the pericardium was opened, it was irrigated daily, either with saline or Dakin's solution, and drainage was provided without the complicating effects of an open pneumothorax or fresh, pleuritic infection. These advantages, plus the additional fact that residual exudate accumulated posteriorly in the oblique sinus (culdesac), in spite of the posterior incision, make it impossible to evaluate exactly the part which was played by the posterior incision in the recovery of the patient.

On the other hand, the pericardial sac drained well through the posterior opening (regardless of the fact that pus puddled in the oblique sinus) and the introduction of the Carrel tubes posterior to the heart was a relatively simple matter. Not only would this have been more difficult through an anterior incision, but the exposure of the heart to the additional length of tubing which would have been required certainly would not have been desirable.

In the past the posterior route has been opposed on the grounds that the pleura might be opened and the patient made to suffer the additional burden of a pneumothorax and fresh pleuritic infection. It may be that this objection is largely theoretical. In consideration of the findings in the case reported here and in that reported by Truesdale, one wonders whether pleural adhesions are not usually present in cases of suppurative pericarditis. They are certainly to be expected when the pericarditis is preceded by a suppurative pleurisy (which is usually the case) and it may well be that the pressure of a distended pericardium and the infection within are sufficiently irritative to the adjacent pleural surfaces to stimulate the formation of adhesions in those cases that are not preceded by empyema. If this is true, the belief that it is necessary to drain anteriorly in order to avoid infecting a healthy pleura is without foundation.

On the other hand, the desirability of draining a suppurative pericarditis without opening and infecting the pleura would not be denied by any one and for this reason it is felt that the posterior approach is particularly suited to those cases which are preceded by empyema. When there has been a preexisting empyema, the presence of adhesions makes it unlikely that free pleura will be entered. Furthermore, the posterior route probably should be restricted to the left side, because the base of the pericardium is lower on the left and the inferior vena cava is not present to obstruct the entrance to the oblique sinus (culdesac). If the expected adhesions are not present and

free pleura is entered, drainage of the space will be provided from the time the infection is introduced and the effects of an open pneumothorax can be compensated by the use of some type of a pressure-maintenance drainage tube (Fig. 4). If this is done, the disastrous effects of the pyopneumothorax might be avoided. I feel it very important, however, to emphasize the importance of frequent irrigations.

The use of Dakin's fluid in this case is deserving of a word of comment. In consideration of the fact that Beck⁴ found that the injection of Dakin's solution into the normal pericardial cavity of the dog was followed by a profound reaction, some of us hesitated to use it in the human. On the other hand, we knew that Dakin's solution had been used in the human pericardium in cases of acute suppurative pericarditis and that a number of cases in which it was used had gone on to complete recovery.^{4, 5} When the exudate became thick and it was discovered puddling in the oblique sinus (culdesac) behind the left atrium, the advantages to be gained from an antiseptic, solvent agent seemed to be of paramount importance and consequently Dakin's solution was substituted for the physiologic salt solution which had been used up to this time. The Dakin's solution accomplished its purpose, for the residual exudate disappeared rapidly after its use was begun. However, it may be too early to conclude that it did not have a harmful effect. It may be, as Beck has suggested, that the fibrinous exudate in suppurative pericarditis protects the pericardial surfaces from the irritating effects of free chlorine. In support of this suggestion he describes his observations that injection of Dakin's solution into the infected pericardium of dogs does not cause pain and bleeding as it does in the normal pericardium.

Another feature in this case was the syndrome produced by the intrapericardial pressure. It presented all of the typical signs of this condition. The importance of their recognition in diagnosis and the mechanism by which they are produced have been described by Beck and Cushing.⁶ As these authors suggest, it is unfortunate that the significance of this syndrome has not been more generally appreciated. Although it was understood that there was interference with the entrance of blood into the right heart, 500 cc. of whole blood were added to the circulation. This was done because the boy was anemic and septic. The result was a near fatality. This experience should be a warning. It demonstrates that an ability to recognize and interpret the signs of intrapericardial pressure is just as important from the standpoint of therapy as it is from the standpoint of diagnosis. Intravenous therapy should be cautiously withheld in these cases, and, if resorted to, fluid should be injected slowly and in small amounts.

SUMMARY

(1) A left sided, posterior approach to the pericardium is recommended as the procedure of choice for drainage of suppurative pericarditis when the pericardial infection follows a left sided empyema.

(2) A case that recovered after the establishment of drainage by this

route is presented, including a detailed description of the history and physical signs, operative procedure and postoperative course.

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PRIMARY CARCINOMA OF THE BRONCHUS TREATED SUCCESSFULLY WITH SURGICAL DIATHERMY *

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THE past decade has revealed a marked increase in the incidence of primary carcinoma of the bronchus. That this increase is not entirely dependent on improvement in diagnostic acumen and the wide use of the bronchoscope as an investigative procedure has been demonstrated by various observers. Junghanns,¹ from a study of patients who came to necropsy, noted an increase in the frequency of the disease in the past seventy-five years, and especially in the last two decades. Maxwell and Nicholson² have come to a similar conclusion from a review of 100 cases of primary carcinoma of the bronchus which were observed at necropsy at St. Bartholomew's Hospital (London, England) since 1867, and estimated that at the present time it comprises one-seventh of all primary carcinomata.

Experience at The Mayo Clinic has been of a very similar nature. Previous to 1925, it was our privilege to see very few cases of primary carcinoma of the bronchus. Since then, such a diagnosis has been made in approximately 250 cases, in 130 of which the diagnosis was confirmed by microscopic examination of tissue which was removed through the bronchoscope. In many of the other cases, the diagnosis has been confirmed at necropsy or by the demonstration of metastatic carcinoma in lymph nodes that have been removed for microscopic examination.

The disease apparently reached its present formidable position somewhat earlier abroad than it did in this country. Staehelin,³ of Basel; Berblinger,⁴ of Jena; Kikuth,⁵ of Hamburg; and Seyfarth,⁶ of Leipzig, as early as 1925, reported an incidence varying from 4.9 to 15.5 per cent of all primary carcinomata. It was not until some years later that similar percentages were encountered in the United States.

While many theories have been advanced to explain the increased frequency of the disease, none has proved entirely satisfactory. It is therefore readily apparent that the treatment of primary carcinoma of the bronchus has come to assume a place of major importance in diseases of the chest.

The greatest obstacle in the treatment of primary carcinoma of the bronchus has been the everpresent problem of early diagnosis. While the diagnosis is comparatively easy in cases in which the lesion is well developed,

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the reverse is true in its incipient form. In many cases, the condition is discovered during the course of a roentgenologic examination of the thorax. It is not uncommon for the first symptom to be caused by a metastatic lesion rather than by the primary growth. Rogers,⁷ in a review of 50 cases of primary carcinoma of the bronchus which came to necropsy, reported that in 44 per cent the first symptom was the result of metastasis rather than of the primary tumor. Carlson and Ballou⁸ have come to a similar conclusion, but point out that metastasis does not always necessarily occur early.

It therefore must be emphasized that any patient who has indefinite pulmonary symptoms, with or without roentgenoscopic findings, should be given the advantage of a thorough bronchoscopic examination, as there is no other means by which a small and early lesion of the bronchus can be recognized definitely.

Some doubt exists in the minds of various pathologists as to what comprises a primary carcinoma of the bronchus. There is no doubt that it is often extremely difficult to classify such tumors because of the small amount of tissue which is obtained through the bronchoscope. The diagnosis requires the greatest experience and skill on the part of the pathologist. In our experience,⁹ primary carcinoma of the bronchus invariably has a high degree of malignancy when graded according to the method of Broders.

There exists a marked difference of opinion regarding the most satisfactory form of treatment of primary carcinoma of the bronchus. Some doubt has been cast on the value of various therapeutic measures and on the accuracy of the pathologic interpretation of the tumor, because of the fact that an occasional patient, who is known to have a primary carcinoma of the bronchus, may live for years without treatment of any kind. It has been our experience, however, that such is the exception rather than the rule. The life expectancy in the cases which we have seen after the establishment of the microscopic diagnosis was slightly more than five months in the cases in which no treatment was employed.

Roentgenotherapy has enjoyed the greatest popularity in the treatment of primary carcinoma of the bronchus, because of its ease of administration and its applicability in all types and stages of the disease. Many observers, however, feel that it is of very limited value. Graham and Singer¹⁰ said that "There is no record in the literature of the successful treatment by radiotherapy of a single case in which the pathologic evidence has been incontrovertible, and in which a five year interval without recurrence has elapsed between the treatment and the time of reporting the case." Our experience with roentgenotherapy has not been as discouraging as that of these authors. While we agree that its benefits are limited, Vinson and Leddy¹¹ have demonstrated that it produces very gratifying results in a small percentage of cases. Vinson¹² has recently reviewed our experience at the clinic with this form of treatment and has found that a number of patients are still alive and well seven years after the diagnosis was established microscopically.

Thoracic surgery has made encouraging progress in recent years in deal-

ing with primary carcinoma of the bronchus. Graham,¹³ in 1934, reported six successful surgical extirpations of malignant growths of the bronchus which had been reported in the literature up to that time. In one of these cases, the patient was alive and well five years later. Since then, additional successful operations have been reported and much is to be hoped for from this method of treatment. It will require, however, some time to evaluate its true value and worth.

The treatment of primary carcinoma of the bronchus directly through the bronchoscope has been found of distinct therapeutic benefit in certain cases. In spite of this, it has not received the attention that it deserves. Bronchial drainage may not only be reestablished, but in favorable cases, the growth may be removed or destroyed by direct excision, surgical diathermy, and the local application of radium.

Jackson¹⁴ was the first to call attention to the feasibility of the bronchoscopic removal of malignant tumors of the bronchus. In 1917, he reported the successful removal of an endothelioma from the bronchus, by bronchoscopy. The patient is alive and well today, 19 years after the operation. This result is unequaled today by any other therapeutic measure. Orton,¹⁵ in 1924, reported the first successful removal of a primary carcinoma of the bronchus. His patient presented all the classic findings which have come to be associated with the disease. In addition, microscopic examination of the tissue which was removed confirmed the diagnosis. He informed us that the patient is alive and well today, 13 years after the removal of the growth. Negus,¹⁶ in 1933, reported the successful removal of an adenocarcinoma of the bronchus by means of bronchoscopy. The patient was alive and well, three and one-half years later. Kernan¹⁷ reported a most instructive group of cases in which there was primary carcinoma of the bronchus that he has treated through the bronchoscope with a combination of excision, surgical diathermy and radon seeds, with most encouraging results. Arbuckle¹⁸ also has used surgical diathermy in the treatment of a patient who had primary carcinoma of the bronchus. The patient lived in comfort while under treatment, for four and one-half years before dying of metastasis. Figi,¹⁹ in 1930, reported the successful destruction of a primary carcinoma of the trachea by surgical diathermy. The patient was alive and well six years later. In 1926, Vinson and Bowing²⁰ first described the value of surgical diathermy in the treatment of tumors of the trachea and bronchi, and have found it of increasing value.

To this very encouraging group, we wish to add the report of a case which emphasizes the value of surgical diathermy in the treatment of primary tracheobronchial carcinoma.

CASE REPORT

A man, aged 65 years, first came to the clinic in May, 1933, complaining of dyspnea and expectoration of a thick mucopurulent material. His difficulty had commenced two years previously and had become progressively worse. On physical examination,

the breath sounds were markedly diminished over the entire right half of the thorax. There were scattered coarse râles. The roentgenograms of the thorax did not disclose anything of diagnostic importance. Examination of the blood and sputum did not reveal anything abnormal. Bronchoscopy was advised, but was rejected, to await further developments. The patient again returned to the clinic August 9, 1933. The dyspnea had increased very rapidly and the patient was having marked distress. There was a marked stridor and he was expectorating mucopurulent material. The physical and roentgenographic findings were the same as they had been at the time of the patient's previous visit to the clinic. Immediate bronchoscopy was advised. On introducing the bronchoscope into the trachea, a large tumor was readily visualized in the lower end of the trachea, almost completely obstructing its lumen. There was a very narrow crescent shaped slit (Fig. 1) between the tumor and the left wall of the trachea, through which the air passed. Purulent material exuded from this slit. It was impossible to determine the origin of the tumor, but it appeared to arise from the outer wall of the left main bronchus. Examination of tissue that was removed from the growth proved to be adenocarcinoma Grade I (Figs. 3 and 4). The condition of the patient was so precarious that immediate increase in the airway was imperative. The



FIG. 1.

FIG. 1.—Bronchoscopic appearance of adenocarcinoma of right bronchus.



FIG. 2.

FIG. 2.—Bronchoscopic appearance of same tumor as in Fig. 1, but after three treatments with surgical diathermy.

tumor, however, was situated too far down in the trachea to obtain relief by tracheotomy. The use of radiotherapy seemed inadvisable because of the possible danger of producing edema and complete tracheal obstruction.

In view of the excellent results which we had had previously with surgical diathermy in the treatment of tracheal tumors, it was decided to apply it here. Two days later, bronchoscopy was performed and a sufficient amount of the tumor was destroyed by surgical diathermy to permit air to pass readily into the lungs. The patient immediately improved and felt much more comfortable than he had before the bronchoscopy. The following day, he coughed out a piece of tumor the size of a bean, which gave him increased comfort. The breath sounds, however, remained diminished over the right half of the thorax. Bronchoscopy was repeated August 18, 1933, a week following the first treatment, and revealed a marked change in the size of the tumor. It now occupied the right half of the transverse diameter of the lower tracheal lumen and the bifurcation could be visualized. Since then, surgical diathermy has been applied to the tumor five times. It was only after the third treatment that the site of the origin of the tumor could be determined definitely. It was found to arise from the lateral wall of the right main bronchus, just below the bifurcation, and filled most of the right main bronchial lumen (Fig. 2). It was not until surgical diathermy was applied to the tumor in the right main bronchus that breath sounds again appeared over

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the right half of the thorax. At the time of the last treatment, December 7, 1934, the only thing discernible was a slight infiltration on the lateral wall of the right main

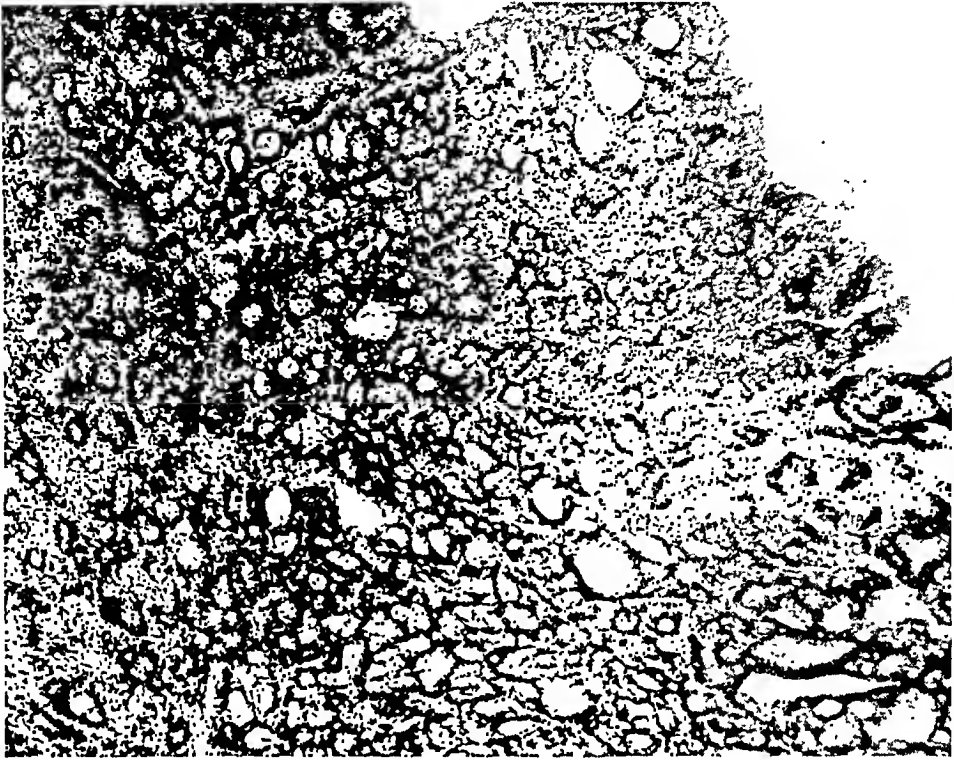


FIG. 3.—Adenocarcinoma of bronchus ($\times 60$).

bronchus at the junction with the bronchus to the right upper lobe. In addition to surgical diathermy, the patient received two courses of roentgenotherapy to the thorax,

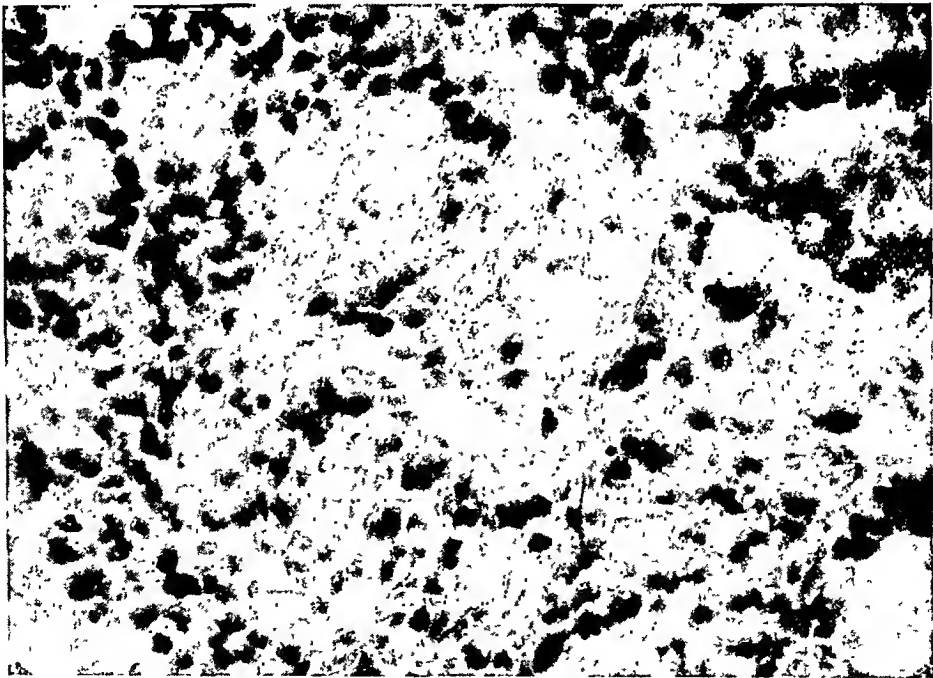


FIG. 4.—Adenocarcinoma Grade I of bronchus ($\times 360$).

in November, 1933, and January, 1934. The patient is in the best of health at the present time, 22 months after the first bronchoscopic treatment, and is performing heavy farm work without the least distress.

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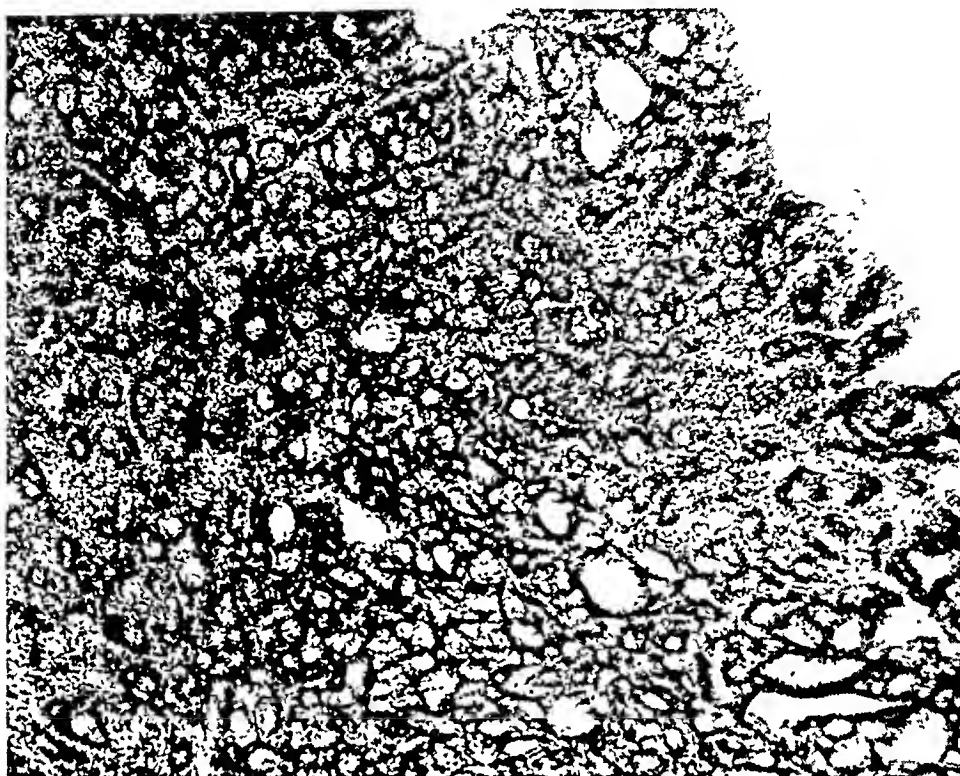


FIG. 3.—Adenocarcinoma of bronchus ($\times 60$).

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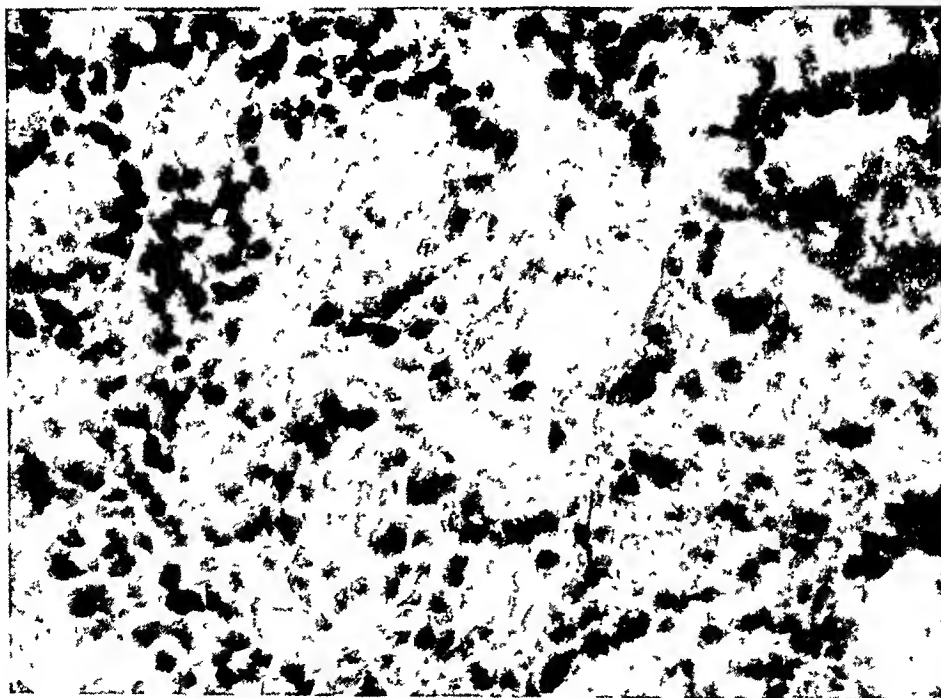


FIG. 4.—Adenocarcinoma Grade I of bronchus ($\times 360$).

in November, 1933, and January, 1934. The patient is in the best of health at the present time, 22 months after the first bronchoscopic treatment, and is performing heavy farm work without the least distress.

In conclusion, it may be said that in certain selected cases, the use of surgical diathermy applied perorally through the bronchoscope will be found of value in the treatment of primary carcinoma of the bronchus.

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CARCINOMA FOLLOWING GASTRIC AND DUODENAL ULCER*

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THE relation of gastric carcinoma to gastric ulcer furnishes a fertile field for controversy, and despite a vast accumulation of literature the question remains undecided. Statistics too often represent a dogmatic personal viewpoint and so suffer from distortion, unconscious and unintentional. This paper presents a statistical analysis of 182 cases of ulcer, and 255 cases of carcinoma of the stomach and duodenum from the surgical services of the Lenox Hill Hospital. No attempt has been made to arrive at any one conclusion, or to prove any particular point.

The compilation includes all cases of gastric and duodenal ulcer operated upon from 1911 to 1930, inclusive, and the gastric carcinomata from 1923 to 1934, inclusive. The gastric and duodenal ulcer cases later than 1930 are not presented because, for the purposes of this paper, the time interval for the development of carcinoma following ulcer is not sufficiently long. The gastric and duodenal ulcers are included in one group because many of the cases where no resection was done were of such nature that the surgeon performing the operation called the lesion "pyloric ulcer," probably because it was impossible at the time to state definitely on which side of the pylorus the ulcer was actually situated. Because of the extreme rarity of carcinoma of the first portion of the duodenum, and the marked frequency of ulcer of this organ, the likelihood of a carcinoma developing at the site of a duodenal ulcer is slight. At the Lenox Hill Hospital there is only one case of carcinoma of the first portion of the duodenum following an ulcer on record (autopsy report). Jefferson¹⁰ collected 30 cases of supposed carcinoma of the duodenum developing in ulcer, and discarded most of them.

For the purposes of this article the cases will be reviewed in two groups: (1) Gastric and duodenal ulcers operated upon which could be followed long enough to determine whether or not carcinoma developed later on. (2) All proven cases of carcinoma of the stomach.

That no absolute proof can be presented is obvious. In the first group are many cases in which no resection was done and where, naturally, no microscopic examination of the ulcer could be made. Hence, the gross examination of the surgeon at the time of operation must be relied upon. That this is not always infallible is well known. The cases in which perforation was the immediate indication for operation are especially unreliable for statistical purposes because a macroscopic diagnosis at the time of operation

* Read before the New York Surgical Society, April 24, 1935.

is not sufficiently accurate to distinguish between ulcer and early carcinoma. If all such perforation cases could be followed for a number of years, it would help somewhat, but, of course, many cannot be found even after a year or two.

The second group (the carcinomata) is unreliable except by assumption, because even if there is a preceding ulcer history, the differentiation between gastric and duodenal ulcer leaves much to be desired. It might be argued that a gastric carcinoma developing after an ulcer history of long standing must have had the carcinoma developing on a gastric ulcer rather than on a duodenal ulcer. On the other hand, however, one might assume that the patient at one time had a duodenal ulcer, which may or may not have healed, and that the gastric carcinoma developed independently. It is true that in such a case the duodenal ulcer should leave some trace of its preexistence, but the gastric carcinoma may have so overgrown it as to eradicate any signs.

From whatever angle the subject is attacked there are widely divergent views. Hauser,¹³ in 1883, was one of the first to prove histologically the close connection between ulcer and carcinoma. He confirmed the previously published assertions of Cruveilhier, Rokitansky, Leube, Lebert, Brinton, and others. Orth¹⁴ called attention to the fact that frequently neither the surgeon nor the pathologist was able to determine the preexistence of an ulcer because the neoplasm had so overgrown the original ulcer, and even its scar, that the evidence was totally eradicated. It is known that frequently these neoplasms develop many years after the original ulcer, and that just as frequently the patients fail to mention or have forgotten that they ever had ulcer symptoms. Again, there are ulcer cases that run a quiescent course without any marked symptoms and these would be lost so far as statistics are concerned, except where a resection is done for carcinoma and the ulcer base is discovered by the pathologist. Five of our cases fall into this group.

Statistics in the literature give the incidence of carcinoma developing on gastric ulcer all the way from 2 to 100 per cent. Zenker claimed that all gastric carcinomata arose from preexisting ulcers. The Mayo Clinic reports an incidence of 4.1 per cent. Albu in a thorough review of the subject of carcinoma of the stomach states that he is inclined to believe that fully one third of the carcinoma cases have their origin in an ulcer. In 1914, Joslin,⁶ in a review of 213 cases of gastric ulcer, reported 12 or 6 per cent had died of cancer up to that time. He admitted that his statistics were complete for only the 46 patients who had died. "In other words, one of every four patients with ulcer of the stomach or duodenum which have been followed to their death, died of cancer."

Interpretations of microscopic sections are subject to great individual variance. Especially is this true in the category of the early degenerative changes, and consequently statistics based upon such examinations will vary greatly. Ewing concludes that the great majority of ulcerating conditions of the stomach are either ulcerating carcinomata or simple benign ulcers. In 1909, MacCarty¹¹ stated "that 71 per cent of our resected specimens for

gastric carcinoma were associated with ulcer." Most pathologists are disinclined to accept all of MacCarty's histologic criteria of malignancy.

The question is of importance to the surgeon doing much gastric work. If one believes that ulcers are the basis for gastric carcinoma in a great percentage of cases, it will lead one to a more radical type of treatment. This last statement may not hold good for many more years, as radical resections for gastric ulcers are becoming more and more frequent. Finney and Hanrahan⁸ state the following: "We do not feel that 70 per cent of chronic ulcerated lesions unaccompanied by tumor or metastases are carcinomatous. We feel that about 85 per cent of simple ulcers are recognizable as such on the basis of chronicity, the character of the edges, and the absence of tumor or metastases. Of the remaining 15 per cent on microscopic examination about 5 per cent will be found entirely benign; another 5 per cent will present recognizable carcinoma; while the remainder will require microscopic study of serial sections to ascertain their true character."

In a comparative review of the cases of gastric and duodenal ulcer with the carcinoma cases, some interesting data have been obtained.

Age Incidence.—The youngest ulcer case was 19 years of age, the oldest 65, the average 39.1. By decades the percentages are:

Years	Percentage	
11 to 20	2.5	
21 to 30	16.0	
31 to 40	28.8	53.8 per cent occurring between the ages of 31 to 50
41 to 50	25.0	
51 to 60	23.7	
61 to 70	4.0	

Among the carcinoma cases the youngest was 25 years, the oldest 80, the average 60.5. By decades the percentages are:

Years	Percentage	
21 to 30	1.17	
31 to 40	10.0	
41 to 50	22.7	59 per cent occurring between the ages of 51 to 70
51 to 60	29.2	
61 to 70	29.8	
71 to 80	3.52	

These ages are very similar to those reported by others. Cases below the age of 30 years of age, however, are uncommon enough to excite considerable interest. Mintz reported a case of carcinoma of the stomach in an 11 year old boy; Marble in a 17 year old girl. Osler and MacCrae collected six reported cases in persons under ten years of age. Smithies¹² published a study of gastric carcinoma in patients under the age of 31, and reported 16 cases.

Sex.—The incidence of ulcers and of carcinoma in the two sexes were quite divergent. Of the 182 ulcer cases 156 occurred in men, and 26 in women; a proportion of 7 to 1. Of the 255 cases of gastric carcinoma 180

occurred in men and 75 in women; a proportion of $2\frac{1}{2}$ to 1. At the Charity Hospital in New Orleans, out of 758 patients suffering from carcinoma of the stomach, 86 per cent were males.

In order to arrive at any definite conclusions regarding the development of carcinoma following ulcer certain criteria were established upon which to base our statistics. Unless a patient had been previously operated upon and a gastric ulcer definitely proved, the following qualifications had to be met:

- (1) A typical ulcer history.
- (2) At least one full year's duration of symptoms without undue loss of weight or signs of cachexia.
- (3) The roentgenographic findings, if any.
- (4) Clinical pathologic findings, if any.
- (5) Pathologic report of carcinoma following ulcer.

About 20 per cent of the 182 cases of gastric or duodenal ulcer could be followed. Of these only one developed carcinoma of the stomach.

CASE REPORT

This man was admitted to the Lenox Hill Hospital in 1919, complaining of epigastric pain after meals for a period of seven years, accompanied by gaseous eructations and occasionally vomiting. There was never any hematemesis, but he admitted having had tarry stools. On admission his hemoglobin was 75 per cent, the urine was negative, as was also the Wassermann. A. C. test meal showed a free hydrochloric acid of 38, and a total of 58. P. C. test meal showed 24 and 40, respectively. The physical examination was negative except for some epigastric tenderness. In 1913, an appendectomy had been performed at the General Memorial Hospital, and he had subsequently been treated medically for an ulcer at both the Roosevelt and the Lenox Hill Out-Patient Departments. May 19, 1919, at Lenox Hill Hospital a posterior gastroenterostomy was done for a "phlegmonous condition of the pylorus." It was noted that the gallbladder and the ducts were normal. A lymph node was excised for microscopic section. The pathologic report by Doctor Humphries stated "hyperplastic lymphadenitis; no evidence of malignancy." In 1922, he was again operated upon and a carcinoma of the stomach removed. He died in October, 1923, from recurrent carcinoma of the stomach with generalized metastases.

Of the 255 cases of carcinoma of the stomach 32 have a distinct and definite previous ulcer history, or had a resection done for an ulcer a portion of which was malignant; a percentage of 12.8. There were 12 other cases (4.8 per cent) that had a history closely simulating ulcer but which was questionable enough to warrant placing them in a separate group. These figures approximate those of Maes, Boyce, and McFettridge,⁷ who reviewed the 758 cases at the New Orleans Charity Hospital, previously mentioned. Using practically the same criteria, they stated that 25 per cent of the cases gave a typical ulcer history.

Mortality.—The operations were performed by 17 surgeons. The hospital mortality of the 255 cases of carcinoma of the stomach is 34.5 per cent. The immediate mortality of the 201 cases operated upon is 33 per cent. Forty-nine (19.2 per cent) of the cases were submitted to resection with a mortality

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of 42.8 per cent. Sixty-three or 24.7 per cent of the cases were treated by gastro-enterostomy with a mortality of 30 per cent. Eighty-nine or 34.5 per cent of the cases permitted no more than an exploratory laporatomy with a mortality of 31.4 per cent. The fifty-three cases not operated upon showed a mortality of 30.2 per cent. These figures agree pretty well with reports from other clinics (TABLE I).

TABLE I

Report from	Per Cent of Cases Resected	Mortal-ity Per Cent	Per Cent of Cases Gastro-enterostomy	Mortal-ity Per Cent	Per Cent of Explora-tory	Mortal-ity Per Cent
Lenox Hill.	19.2	42.8	24.7	30	34.5	31.4
St. John, F. B. ² . . . . .	....	43.7	....	26.6	....	....
Maes, Boyce, and McFettridge	17.5	51.4	41.5	43.6	....	....
Oughterson ³ . . . . .	....	40.3	....	28.3	....	....
Salzstein and Sandweiss ⁴ . . . . .	....	64.0	....	66.0	....	....
Persson, M. ⁵ . . . . .	....	28.0	....	23.1	....	17.1
Anschütz and Konjetzni. . . . .	....	34.5	....	28.5	....	9.0
Balfour.	200 cases	5.0	....	....	....	....

In New York the follow-up of the cases is most difficult. We were able to follow only about 25 per cent of the cases for any length of time. Some disappeared without a trace as early as three months after discharge. The European clinics with their more stable populations and police registration can pursue their follow-ups much better. Persson⁵ was able to follow all but three out of 269 cases for as long as 20 years.

Of the 43 that were traced at Lenox Hill, two cases lived two years. One case is still alive and well after four years. One case is alive and well after five years. One case is alive after eight years. Although he complains of abdominal symptoms and does not gain weight, no evidence of recurrence can be found. One case is alive and well after nine years. One case died from a recurrence 11 years after a resection, having been well and enjoyed life until a few months before death. The average length of life of the remaining cases traced was 5.6 months.

SUMMARY

- (1) One hundred eighty-two cases of gastric and duodenal ulcers operated upon from 1911 to 1930, and 255 cases of carcinoma of the stomach, of which 201 were operated upon, are reviewed.
- (2) Among the ulcer cases one developed carcinoma.
- (3) Of the carcinoma cases 32 gave a history typical of ulcer, or the pathologic specimens showed ulcer coexistent with carcinoma.
- (4) Twelve others had a history closely simulating ulcer, but questionable enough to be placed in a separate group.

(5) Even in the cases of associated ulcer and carcinoma both are sufficiently frequent to raise the question of possible coincidence.

I wish to express my thanks and appreciation to Dr. Walter T. Stenson for his assistance in gathering the statistics of the ulcer cases from 1911 to 1924, and to Dr. Francis D. Huber for placing his compilation of the ulcer cases from 1925 to 1930 at my disposal.

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DISCUSSION.—DR. CARL EGGERS (New York) said that his interest had been aroused by the statistics presented by Doctor Sauer. He had been under the impression from clinical observation that ulcer and carcinoma were not commonly associated, and that cancer is rarely grafted onto an old ulcer. Cancer patients come in as cancer patients with a short history of disability, and without any previous symptoms suggestive of disease of the stomach, this very insidiousness of onset being most often responsible for late diagnosis. If a definite association between ulcer and carcinoma is demonstrated in a large number of cases, it behooves one to do radical surgery even if ordinarily not radically inclined in regard to the therapy of ulcer. The greatest aid in determining malignancy before operation is received from the radiographic department. Although examination of the stomach contents is often of value. On the whole it has been the insistence of the roentgenologist, particularly in lesions of the prepyloric region, that has influenced surgeons to operate radically.

Among 54 cases of gastric carcinoma in his own experience, there were 25 resections, of whom five died, or an operative mortality of 20 per cent; seven patients died at home, and 13 are still living. Of those living, one has been well for ten years, two for nine years, one for five years, two for three years, one for two years, one for one year and five less than one year.

With regard to lymph node involvement at the time of operation, the 16

per cent still living after five years had no involvement of lymph nodes. On the other hand, one patient who lived nearly five years, and another who lived four years, had involvement of the nodes at the time of operation. A third case who died of acute cholecystitis and cholangitis two years and three months after a gastric resection for carcinoma of the stomach with metastasis, failed to show any evidence of metastases after a careful autopsy.

It is frequently not possible at the time of operation to determine definitely whether enlarged lymph nodes are involved. Certainly they should never make one decide against a radical operation as long as they are removable. Most of these patients have enlarged lymph nodes which show simple hyperplasia. The results with gastro-enterostomy had not been good, there being 50 per cent hospital mortality, and exploratory laparotomies had been followed by a mortality of 18 per cent.

Reviewing all the histories of the 54 cases in an attempt to determine the relationship of ulcer to cancer, it was found that in 18 per cent there was an old or a more recent history of some gastric disorder, which in a few was strongly suggestive of ulcer. Among the 25 patients in whom a resection was done, the pathologist was reasonably certain that in four there was association of ulcer and carcinoma.

Doctor Eggers felt that, on the whole, there is opportunity to improve results in carcinoma of the stomach. If the patient could be seen a little earlier and if good radical surgery, including the affected portion of the stomach and its lymph node drainage area, could be done, better results might be expected. Several factors are of help in this, one being earlier radiographic examination of patients with suspicious stomach symptoms as a step to earlier diagnosis, and the other improvement in preoperative and operative technic. Emptying the patient's stomach and keeping it clean is of the greatest value as a pre-operative measure. This should be supplemented by the administration of adequate quantities of fluids with glucose and perhaps transfusions before and after operation. During operation, the use of a de Petz sewing machine is of the greatest value, avoiding leakage and thereby preventing contamination, and shortening the time of operation.

DR. F. W. BANCROFT (New York) stated his belief that if cases of carcinoma occurring as a result of ulcer are to be analyzed statistically, there should be a further subdivision of the region to be considered. Duodenal ulcer has already been ruled out, but one should go further and separate lesions of the lesser curvature from the pyloric antrum. In other words, in penetrating ulcers of the lesser curvature of the stomach malignancy is relatively rare. The site where malignancy apparently occurs most often is in the pyloric antrum. If one proceeds on the assumption that carcinoma is apt to occur in the cardia or on the lesser curvature, and operate on that case without giving it a chance to heal under medical treatment, the mortality is raised to a considerable degree. In one of Doctor Bancroft's cases, Dr. Lewis Gregory Cole divided the ulcer in half and sent sections of each half to a group of eight pathologists. However, he labeled each half with a different name so that the examiners were unaware that they came from the same individual. One group of eight described one side of the ulcer as benign, while six of the eight described the other half as carcinoma, and the remaining two as some form of malignancy. There was apparently a perfectly benign side to the ulcer, on which all agreed, not knowing it came from the same case, and on the other side almost all agreed that it was carcinoma, and all that it was malignant.

DR. RICHARD LEWISOHN (New York) said that the operative mortality in carcinoma of the stomach will always be comparatively high if one is will-

ing to extend the indications for resection as far as possible. It is very easy to keep the mortality down if only the favorable cases of gastric carcinoma are subjected to a radical resection.

After looking over the cases of carcinoma of the stomach at Mt. Sinai Hospital recently, Doctor Mage told Doctor Lewisohn of a very interesting observation, showing how hopeless today is the surgical attempt to cure carcinoma of the stomach. Of 100 cases entering Mt. Sinai Hospital with carcinoma of the stomach, only two are alive and well after five years. He arrived at this figure in the following manner: A certain percentage are admitted and refused operation; another percentage is turned down as inoperable; another group is subjected to operation only to have found an inoperable condition. In a fourth group, a gastro-enterostomy is performed, and only 33 per cent of those coming up to the operating room are not too far advanced to have a partial or subtotal gastrectomy performed. Among the latter group very few are alive and well after five years. This shows again the hopelessness of the condition at the present time. All suspicious cases of lesser curvature ulcer should be subjected to radical surgery, in Doctor Lewisohn's opinion. In spite of the excellent roentgenographic work in all hospitals, a number of cases reported as benign by the radiographic department turn out, at operation, to be malignant. Any case that does not respond very quickly to medical treatment should be subjected at an early date to operative exploration. The mortality for subtotal gastrectomy in gastric carcinoma at Mt. Sinai Hospital is about 33 per cent, this comparatively high figure being due to the fact that wherever possible an attempt is made to be radical and not to turn down the case as inoperable.

DR. ALLEN O. WHIPPLE (New York) stated that in Presbyterian Clinic there are now eight patients who have reported for a 10 to 18 year period following resection of carcinoma of the stomach, giving a percentage of 33 per cent of patients who have been resected and followed for a period of ten years. These cases, however, have belonged to a relatively benign group of carcinoma, the fungating type that is not as malignant as the infiltrative type.

JEJUNAL ULCER *

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THE development of jejunal ulcers following operations performed in the treatment of diseases of the stomach and duodenum is of interest to the surgeon not only because it constitutes a serious surgical complication, but also because the lesion is one for which the primary procedure is responsible. Jejunal ulcer is associated with the development of gastric surgery, and therefore experience with the condition has likewise gradually increased.

INCIDENCE

A great mass of information has accumulated on this subject, and it appears that there is no surgical procedure uniting the stomach and jejunum that will offer a guarantee against the subsequent development of jejunal ulcer. Berg,¹ Lewisohn,⁷ Strauss,²⁰ Hurst and Stewart⁵ all condemn gastrojejunostomy, which is the procedure that has been used more often than any other in the treatment of peptic ulcer. Their statistics suggest that this operation is complicated by the formation of jejunal ulceration in 20 to 52 per cent of cases. Surgeons in Germany have also discarded gastrojejunostomy and in its place they advocate some form of partial resection for the treatment of peptic ulcer. Others are of the opinion that European surgeons are dealing with an entirely different type of lesion than that ordinarily encountered among patients in America. Consequently, the statistics obtained in these two countries are not comparable.

There are many who believe that while jejunal ulceration is not entirely unavoidable after conservative operations, the incidence of such ulceration is too small to justify the substitution of radical measures. Paterson¹⁴ found the incidence of jejunal ulcer to be 2.4 per cent in a series of 495 operations, whereas Moynihan reported an incidence of 1.6 per cent in a series of 613 patients who underwent gastrojejunostomy. The occurrence of the lesion varied between 1.2 and 3.2 per cent in the two series of cases published by Walton^{22, 23, 24} in which gastrojejunostomy was employed for duodenal ulcer. Luff⁸ traced 744 patients who had been operated on for duodenal ulcer and found that only 21 had jejunal ulcer subsequently. Wright²⁶ believes that secondary ulcer occurs in about 6 per cent of patients after gastrojejunostomy for duodenal ulcer. Wilkie's²⁵ statistics revealed an incidence of 3.5 per cent in all cases in which he performed gastrojejunostomy for ulcer. Most of the figures resulting from studies of work done in this country are quite similar

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to these, for the incidence varies from 2 to 5 per cent if the statistics of Lewisohn and Strauss are excluded.

In a recent article on the subject of jejunal ulcer, Heuer has made a brief and concise statement of the general trend of thought with respect to the treatment of these lesions. He has drawn his conclusions from his own experiences and from published reports of those of other authors, and he says that the results of 17 authors from various countries show that recurrent or jejunal ulcer follows gastro-enterostomy in from 0.9 to 6.9 per cent of the cases, the average incidence being 3 per cent. He found that the statistics given by eight authors showed that recurrent or jejunal ulcer follows partial gastrectomy in from 0.6 to 6 per cent of cases, or an average of 1.9 per cent.

In the 20-year period beginning in 1912, when the first operation for jejunal ulcer was performed at the clinic, 597 patients have received surgical treatment for this condition. The primary operation was performed at the clinic in 278 cases and elsewhere in 319. From 1906 to 1931, gastrojejunostomy has been carried out at the clinic in 10,338 cases in the treatment of duodenal ulcer. If one considers only the 251 patients with proved jejunal ulcer who underwent gastrojejunostomy for duodenal ulcer at the clinic, the incidence of jejunal ulcer is found to be 2.4 per cent. However, it has been stated that the longer the period intervening after gastrojejunostomy, the higher the incidence of jejunal ulcer will be. In order to prove or disprove this assertion, we studied the course of the 251 patients from the time of primary operation to and including the year 1931. As Table I indicates,

TABLE I
Incidence of Jejunal Ulcer after Gastrojejunostomy Performed at the Clinic for Duodenal Ulcer

Period During Which Gastro- jejunostomy Was Performed	Total Patients	Returned with Jejunal Ulcer	
		Number	Per Cent
1906 to 1911.....	508	14	2.8
1912 to 1921.....	4383	121	2.8
1922 to 1926.....	3065	70	2.3
1927 to 1931.....	2382	46	1.9
Total.....	10,338	251	2.4

some of them underwent the primary operation in 1931. The 26-year interval between 1906 and 1931 has been divided arbitrarily into subperiods for the purpose of determining the incidence of jejunal ulcer after gastrojejunostomy. The incidence is greater in the first group than in the last, which is explained by the fact that a longer time had elapsed since gastrojejunostomy and consequently more of the individuals who will develop jejunal ulceration probably were included. A similar situation seems to obtain if a comparison is made

JEJUNAL ULCER

between two consecutive groups. These findings tend to support Hurst's and Stewart's contention, but only to a certain extent, for it can be seen that although there is a gradual increase in the incidence of jejunal ulcer coincident with the time elapsed since gastrojejunostomy, a maximal incidence is eventually reached, as is shown by a comparison between the first and second groups. In other words, 2.8 per cent probably represents more nearly the true incidence of jejunal ulcer than is shown in the other groups. We have stated advisedly that this is approximately the true incidence of jejunal ulcer following gastrojejunostomy for duodenal ulcer, for we have been unable to trace all of our patients who have undergone this operation. Nevertheless, we are confident that there are comparatively few patients who have not reported to us when symptoms of jejunal ulceration developed.

Age and Sex.—The age and sex of patients with jejunal ulcer are also of interest. A study of the age distribution reveals that the highest incidence occurred during the third and fourth decades (Table II). Although jejunal

TABLE II
*Age and Sex of Patients with Jejunal Ulcer Following Gastrojejunostomy
(1912 to 1931)**

Age, Years	Males, Per Cent	Females, Per Cent	Total, Per Cent
10 to 19.....	0.2	4.7	0.5
20 to 29.....	8.7	9.3	8.7
30 to 39.....	33.1	32.6	33.1
40 to 49.....	36.8	27.9	36.2
50 to 59.....	16.1	16.3	16.1
60 to 69.....	4.7	9.3	5.0
70+.....	0.4	0.0	0.3
Mean age.....	41.8 years	42.6 years	42.5 years

Ratio of males to females: 12.9 to 1.

* The first patient with jejunal ulcer was encountered in 1912, but he had undergone gastrojejunostomy at the clinic in 1906.

ulcer occasionally develops in those of advanced years (the oldest in this series being 71 years of age) the statistics reveal that, like peptic ulcer, the disease is primarily one of young adult life. And similarly, males seem to be more susceptible than females, for the proportion is at least 4 to 1 for primary ulcer, and approximately 13 to 1 for jejunal ulcer. However, the age distribution for the two sexes is about the same.

Effect of Primary Lesion.—The nature of the primary lesion appears to be an important factor in the subsequent development of jejunal ulcer.

Although the incidence of jejunal ulcer following gastrojejunostomy for gastric ulcer is extremely low, the lesion is rarer still following the same operation performed in the treatment of gastric carcinoma. In this respect, the results of the present investigation agree with the experience of others,

for in only one case was a jejunal ulcer observed under such circumstances. This seems particularly significant because of the anacidity or hypo-acidity that is usually associated with carcinoma of the stomach. Although it might be argued that these individuals do not live sufficiently long to form jejunal ulcers, a review of data on 393 patients living five years or more following partial gastrectomy for carcinoma of the stomach did not reveal one instance of subsequent jejunal ulceration. In the series of 597 patients with proved jejunal ulcer, the original lesion was a gastric ulcer in only 20 cases. Furthermore, in this group not a single jejunal ulcer developed in cases in which local excision combined with gastrojejunostomy seemed sufficient treatment for a small malignant gastric ulcer.

Jejunal ulcer may therefore be considered as a complication limited primarily to cases of duodenal ulcer in the treatment of which the jejunum has been anastomosed to the stomach. Table III shows the various procedures employed in the treatment of the primary lesion in the cases in this study.

TABLE III
Type of Operation Done for Primary Lesion

	Duodenal Ulcer	Gastric Ulcer	Diagnosis Duodenal and Gas- tric Ulcer	Location? (Peptic)	Carcinoma of Stomach	Total
Gastrojejunostomy at clinic.....	251	5				256
Gastrojejunostomy else- where.....	202	3		93		298
Total.....	453	8		93		554
Enfolding ulcer and gas- trojejunostomy at clinic	3	1				4
Enfolding ulcer and gas- trojejunostomy else- where.....	1					1
Total.....	4	1				5
Excision of ulcer and gas- trojejunostomy at clinic	4	9				13
Excision of ulcer and gas- trojejunostomy else- where.....	7	1	1	5		14
Total.....	11	10	1	5		27
Partial gastrectomy at clinic.....	2	1	1		1	5
Partial gastrectomy else- where.....	4	—	—	2	—	6
Total.....	6	1	1	2	1	11
Total.....	474	20	2	100	1	597

ETIOLOGY

It has long been recognized that jejunal ulcer may develop after any operation in which the stomach is anastomosed to the jejunum. Although the probable causes of this lesion have been discussed at length in the literature, there is no uniformity of opinion in regard to the nature of the etiologic agent. In view of this fact, a few of the more widely accepted theories will be considered.

Much has been written concerning the importance of infection in the formation of an anastomotic ulcer. The frequency with which gastritis and jejunitis is associated with these lesions is emphasized by some authors. In addition, Saunders¹⁸ has succeeded in isolating a streptococcus which he claims to be specific. Rosenow and Sanford^{16, 17} were also of the opinion that foci of infection play a major part in the etiology of jejunal ulceration. On the other hand, Steinberg and Proffitt¹⁹ are convinced that infection is only of secondary importance, because the mucosa at the juncture of the stomach and jejunum is particularly vulnerable to acid pepsin, especially when the general resistance of the subject is lowered. Dragstedt and Vaughan,^{2, 3} Mann and Williamson¹⁰ seem to be of the opinion that the ulcers which they studied were primarily due to chemical and mechanical factors.

It was formerly thought that the use of unabsorbable suture material contributed to the formation of jejunal ulceration. It is not difficult to understand how this opinion originated, for when one finds a piece of silk in the center of a jejunal ulcer, it is not unreasonable to assume that it might offer an explanation of the presence of the lesion. In this study, portions of suture material were found in 23 cases, constituting 3.9 per cent of the whole group. However, since catgut is employed almost always at the clinic in operations for benign peptic ulcer, we now know that anastomotic lesions cannot be prevented merely by the use of absorbable suture material.

Stress is frequently laid on the manner in which clamps are applied to the tissues in performing operations on the upper portion of the gastro-intestinal tract. Experimental work, however, has repeatedly demonstrated that acute traumatic ulcers heal rapidly and show no tendency toward chronicity; accordingly, we would expect these lesions to be healed by the time symptoms of jejunal ulcer usually appear. Furthermore, it is difficult to conceive of these instruments being of any etiologic significance if one takes into consideration the fact that anastomotic lesions are rarely found when the clamps were applied, and also that jejunal ulcer may even develop when the anastomosis is made without clamps.

Some of the various errors in technic which have been suggested as possible causes of jejunal ulceration are: (1) too small an opening in the anastomosis; (2) placing the stoma too high on the stomach; (3) inclusion of inflamed gastric mucosa in the anastomosis; (4) formation of a spur by redundant mucous membrane; (5) invagination of the jejunum into the stomach; (6) failure to approximate mucous membrane to mucous membrane;

(7) kinking of the distal loop, and (8) formation of a hematoma. While all of these factors must be considered and then be eliminated in order to obtain satisfactory results from the operation, they do not in themselves constitute the entire answer to the problem.

Of all the factors that have been mentioned as having a direct bearing on the formation of jejunal ulcer, that of hyperchlorhydria has received the widest acceptance. Vanzant, Alvarez, Berkson and Eusterman,²¹ while engaged in establishing normal standards for gastric acidity, noticed that the value for free hydrochloric acid in males was higher than that in females. They then carried their investigation a step farther and discovered that patients with duodenal ulcer had higher values for free hydrochloric than those with gastric ulcer. Since almost everyone is agreed that duodenal ulcer is usually associated with hyperchlorhydria, it seemed of interest to study the gastric acidity of the patients who had the primary operation for gastric ulcer at the clinic.

In 17 of the 20 cases of gastric ulcer in which jejunal ulcer developed and in which gastric acidity was determined before gastrojejunostomy was performed, the average acidity was found to be 42.2 units. According to the standards of Vanzant and others, the average gastric acidity of a normal group of the same sex and age would be 42.5, that is, about the same value as that found for the group of patients with gastric ulcer. Vanzant and others, however, found that in a general group of persons with gastric ulcer, the average acidity is lower than normal by about 6 units. It would therefore seem that the gastric acidity in the group in which jejunal ulcer developed later was higher than that ordinarily found in cases of gastric ulcer. Increased gastric acidity may in part explain the development of jejunal ulcer in these particular cases. On the basis of such a theory, Walton^{22, 23, 24} also explained the predominance among males of anastomotic lesions after operations for duodenal ulcer. It might even be argued that there are certain individuals, constituting 3 to 4 per cent of all those who receive treatment for peptic ulcer, who congenitally have an abnormally high gastric acidity, and that it is probably in these cases that jejunal ulcer develops subsequently.

The problem, however, is not as simple as this, for it should be stated that Vanzant and others did not find any greater acidity in the group with duodenal ulcer in which jejunal ulcer developed than in the group with duodenal ulcer in which a jejunal ulcer did not form after gastrojejunostomy. In addition, it must also be remembered that marked reduction in gastric acidity, or even achlorhydria, does not insure against the development of jejunal ulcer. Furthermore, it is evident that, at least at times, some factor of a different nature has more influence; for example, the values for pepsin are usually increased in the presence of duodenal ulcer, and there apparently is a higher degree of correlation between the amount of this ferment and the severity of the symptoms. In addition, one should not discard the idea that in the etiology of jejunal ulceration there probably are other factors as yet unknown, for jejunal ulcer may develop following gastrojejunostomy in

cases in which there really never was an ulcer either in the stomach or in the duodenum.

PATHOLOGY

We have found that 90 per cent of the jejunal ulcers were single, and that 48 per cent were situated in the line of the anastomosis. Walton^{22, 23, 24} was of the opinion that the origin of all of these lesions can be traced by a linear scar to the site of union of the stomach and jejunum. Although our records indicate that only 29.5 per cent of the ulcers were on the jejunal side below the stomach and 7.6 per cent were on the gastric side of the opening, nevertheless we believe that the majority of these lesions are jejunal. In 14.3 per cent of the 597 cases the site of the lesion was not stated.

The characteristics of jejunal ulcer are quite similar to those ordinarily observed in peptic ulcer. If the lesion is acute, the walls are soft and there is danger of perforation. However, the chronic type of ulcer has thick, calloused walls and frequently has a deep crater. More than 43 per cent of the lesions were described as being of the penetrating variety. Pater-son^{12, 13, 14} has stated that perforation is rare when the ulcer is situated in the stoma, but that ulcers situated at some distance below the anastomosis occasionally perforate before they are sealed off by a protective covering. When perforation occurs into the peritoneal cavity, an immediate operation is indicated. Fortunately, this does not happen frequently. In the process of protecting the base of an ulcer, adjacent structures may become involved and marked edema may ensue as a result of the inflammatory reaction. Owing to the proximity of the colon, it is particularly vulnerable, and if the penetrating tendency continues, a gastrojejunocolic fistula may develop. This occurred in 52 cases in our study, or in 8.7 per cent. Occasionally, when the condition is neglected, the abscess may involve the abdominal wall and finally erode through the skin. On the other hand, the ulcer will sometimes tend to heal, but, as a result of contracture of the scar tissue, various degrees of obstruction will be produced in the anastomotic stoma, and even in the colon if it is involved. In approximately 10 per cent of the cases there was evidence of stenosis of the stoma.

SYMPTOMS

The presence of another ulcer should be suspected if there is a recurrence of symptoms more or less identical with the original manifestations, including pain following gastrojejunostomy or resection. The period of relief before symptoms returned after gastrojejunostomy is given in Table IV.

In 34 per cent of our cases in which jejunal ulcer was proved, the symptoms reappeared within six months after the primary operation and in approximately 50 per cent within a year. This fact is extremely important, for until it was recognized that a high percentage of jejunal ulcers would develop soon after the primary operation, the condition was frequently neg-

TABLE IV
Period of Relief Following Gastrojejunostomy

Period of Relief, Years	Cases	Per Cent
Less than $\frac{1}{2}$	199	34.0
$\frac{1}{2}$ to 1	73	12.5
1 to $1\frac{1}{2}$	60	10.1
$1\frac{1}{2}$ to 2	30	5.1
2 to 3	37	6.3
3 to 4	28	4.8
4 to 5	15	2.6
5 to 10	62	10.3
10 to 15	9	1.5
15 to 20	3	0.5
Not stated.....	70	12.0
Total.....	586	100.0

lected for a length of time sufficient to permit perforation or the onset of other serious complications which greatly increased the risk of reoperating. Table IV also shows that the percentage of cases in which jejunal ulcer developed diminishes rapidly after the two or three year period immediately following the primary operation. However, it has been found that a patient may enjoy complete relief for years and then either gradually or suddenly have evidence of the presence of the disease.

When the symptoms recur after operation, complexities are introduced by virtue of the possibility of the presence of jejunal ulcer or reactivation of the original lesion, which is usually a duodenal ulcer. The presence of a jejunal ulcer, however, is usually attended by greater severity and progressiveness of the clinical course and more intractability to treatment. Owing to the fact that ordinarily jejunal ulcer does not tend to heal, there is a greater tendency to hemorrhage and to other complications. In many respects the symptoms accompanying chronic uncomplicated jejunal ulcer are strikingly similar to those resulting from the primary lesion, except that the form and area of deep tenderness has usually shifted downward toward the umbilicus, and at times to the left of it. When the jejunal lesion is of the penetrating type, pain may extend even lower in the abdomen. This pain was described as being severe in 24 per cent of the cases and as moderate in 40 per cent. Forty-two per cent of the patients complained of a penetrating type of pain extending through to the back. The periods of relief from pain are usually brief and incomplete. Other characteristics are likely to be: early onset of distress after eating, ineffectiveness of alkalis, and eventual incompleteness or brief duration of relief from all measures. In this study, 33.7 per cent of the patients gave a history of vomiting of blood or of passing tarry stools. Melena is more frequent than hematemesis, and oozing with resulting anemia is not uncommon.

The symptoms and signs of diagnostic importance are: (1) gastric hemorrhage, especially in the absence of bleeding before the primary operation; (2) gross gastric retention; (3) gastrojejunocolic fistula, and (4) progressive course and lack of satisfactory response to medical treatment. Since penetration characterizes the majority of jejunal ulcers, this tendency and the development of grave complications are the best justification for early surgical intervention in the severe intractable cases.

Gastrojejunocolic Fistula.—It is interesting to observe that gastrojejunocolic fistula practically never occurs in women, for of the 52 cases in this study in which fistula was present, in only one was the patient a woman. Judging from the statistics obtained during this investigation, the incidence of fistulous communication with the colon in cases of jejunal ulcer is 8.7 per cent. However, the records frequently contained reference to impending perforation, and it is evident that considerable risk is assumed in deferring surgical interference in intractable cases of jejunal ulcer or in those in which there are symptoms of perforated jejunal ulcer.

One of the most common manifestations of gastrojejunocolic fistula is frequent defecation. The stools may be described as watery, fatty, or lienteric. Other symptoms may be belching of gas with fecal odor, or less frequently, fecal vomiting, marked and rapid loss of weight in spite of unimpaired or increased appetite and intake of food, dehydration, and loss of strength. Colicky lower abdominal or circumumbilical pains are frequently experienced. If the fistula is large, diarrheal movements occur soon after food is taken into the stomach; if the opening is small, and if it communicates with a distant segment of bowel, the cardinal symptoms are likely to be intermittent, for the fistula may close for a time and normal intestinal function ensue. With establishment of a fistula, pain often ceases. Abdominal palpation seldom if ever reveals a mass. If one is present, it is the result of extensive adhesions or regional inflammation. Because of the great variability in the physical signs, they are not reliable. The evolution of fistula is progressive and, unless surgical intervention is undertaken, the outcome is usually fatal.

In view of the fact that about 50 per cent of the patients who have jejunal ulcer detect symptoms within the first year, the length of time that elapses between the primary operation and that instituted for jejunal ulcer is surprising, especially when one considers that the discomfort is usually severe. In this regard Table V is of interest. When one considers each year individually, it is found that surgical intervention for jejunal ulcer is more frequent the second year after the primary operation, which is as one might expect. However, the average interval between primary and secondary operation for the entire group is 5.7 years.

TREATMENT

Preventive.—The most effective means of preventing jejunal ulceration after the surgical treatment of peptic ulcer is to avoid gastrojejunal anas-

TABLE V

Interval between Gastrojejunostomy and Operation for Jejunal Ulcer

Interval, Years	Gastrojejunostomy Performed					
	At Clinic		Elsewhere		Total	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
0 to 1.....	27	9.9	20	6.4	47	8.0
1 to 2.....	44	16.2	46	14.7	90	15.4
2 to 3.....	41	15.0	40	12.8	81	13.8
3 to 4.....	25	9.2	25	8.0	50	8.5
4 to 5.....	22	8.1	32	10.2	54	9.2
5 to 6.....	19	7.0	26	8.3	45	7.7
6 to 7.....	18	6.6	29	9.3	47	8.0
7 to 8.....	12	4.4	14	4.5	26	4.4
8 to 9.....	14	5.1	13	4.1	27	4.6
9 to 10.....	14	5.1	15	4.8	29	5.0
10 to 15.....	28	10.1	40	12.8	68	11.6
15+.....	9	3.3	13	4.1	22	3.8
Total	273	100.0	313	100.0	586	100.0
Average	5.3 years		5.8 years		5.7 years	

tomosis in cases in which gastric acids are high and little or no pyloric obstruction exists. We now know that jejunal ulcer is likely to occur in individuals of this type, particularly if they are young and of a nervous, high-strung temperament. Consequently, if surgical treatment of a peptic lesion becomes necessary in such cases, it is preferable to carry out some form of local operation on the duodenum and maintain normal gastro-intestinal continuity whenever it can be done. For this purpose, excellent results have been obtained from excision of the lesion, together with the anterior two-thirds of the pyloric sphincter muscle, with closure as a gastroduodenostomy. This procedure can be used not only in cases of duodenal ulcer, but also in those of gastric ulcer situated near the pylorus. In cases in which it is not advisable to disturb the primary ulcer, the lower end of the stomach may be anastomosed to the first portion of the duodenum, as a lateral gastroduodenostomy. This operation is completed just as one would perform gastrojejunostomy without clamps. All of these patients should be impressed with the need of adhering to a regulated diet. A study of the trend of surgery at the clinic during the last ten years revealed more than a 100 per cent increase in the number of operations that maintained the more normal gastric physiologic action. On the other hand, it is not always possible or desirable to perform a local operation on the duodenum because of the type of the lesion or the presence of complicating factors.

The value of any surgical procedure depends on the safety with which it can be performed and the relief to be anticipated. Consequently, gastrojejunostomy still constitutes an excellent form of treatment for peptic ulcer

JEJUNAL ULCER

in some instances, for not only is the mortality low, but there is also an excellent chance of cure, as 86 to 88 per cent of the patients so treated obtain satisfactory results. However, there is some difference of opinion as to the relative merits of the anterior and the posterior methods of approach. We have always been partial to posterior gastrojejunostomy, but we do not hesitate to perform the anterior operation if technical difficulties are encountered that make the latter procedure more desirable. From the standpoint of jejunal ulceration, there seems to be little choice between the two operations. The higher incidence of jejunal ulcer following anterior gastrojejunostomy reported by some can probably be accounted for by the frequency with which entero-anastomosis is combined with that procedure.

One is immediately impressed by the small number of jejunal ulcers that develop after partial gastrectomy. This, however, is easily explained by the fact that this procedure was used infrequently, especially in the treatment of duodenal ulcer. The immediate mortality with partial gastrectomy, even in the hands of the most skilled surgeons, is variously stated as being between 5 and 8 per cent, whereas that for gastrojejunostomy usually averages less than 2 per cent; there is ample justification, therefore, for the employment of gastrojejunostomy in the treatment of peptic ulcer.

Medical.—There is still some diversity of opinion as to the advisability of instituting medical treatment in cases of jejunal ulcer. Unless emergency measures are required, considerable benefit may be derived from a supervised medical and dietary regimen, especially when the lesion is a jejunitis and not a true ulceration. We have been impressed with the excellent results which have seemed to come from the supplementary use of duodenal extract. On this account, we feel that it should be given a trial not only in cases of primary peptic ulcer, but also in those cases in which individuals are so unfortunate as to have a jejunal lesion subsequently, especially if the suffering is not too severe and prompt improvement ensues. The product was investigated experimentally by Ivy.⁶ At the clinic, Rivers¹⁵ has used the extract as supplementary treatment in more than 50 cases since October, 1934; however, a sufficient period has not elapsed to be sure of the permanency of the results. In some instances complete remission of symptoms has followed employment of 60 to 90 grains (4 to 6 Gm.) of duodenal extract for varying periods of eight days to four weeks, and when roentgenologic investigation of the digestive tract was made subsequently, all roentgenologic signs of the ulcer had disappeared.

The medical management of jejunal ulcer should be undertaken only when there is an opportunity to begin the treatment while the lesion is in an early stage. In some of these cases, a carefully supervised and regulated regimen will not only keep the patient comfortable, but it will eventually permit him to gain control of the condition. In view of the known tendency of jejunal ulcer to be accompanied by serious complications, considerable responsibility is assumed by anyone who persists in treating jejunal ulcers by medical measures regardless of unsatisfactory results. Such a plan very often permits

grave complications to develop, which materially increase the risk of treatment when surgical intervention finally becomes imperative. The patient's delay in seeking advice is another factor contributing to that situation; often he waits until there is a great deal of inflammatory reaction about the ulcer or even until a colic fistula has developed.

Choice of Operation for Jejunal Ulcer.—Secondary operation in a given case must necessarily depend to a large extent on the nature of the primary procedure. The development of a jejunal ulcer suggests that the patient probably will not show a greater degree of toleration to another anastomosis between stomach and jejunum, and that when a new relationship is effected, it should reestablish the normal continuity as nearly as possible. One should approach the problem with an open mind and be prepared to perform the operation that seems most feasible.

If the primary ulcer in the stomach or duodenum has healed and the pylorus is unobstructed, the most judicious procedure may be to disconnect the gastrojejunal anastomosis and excise the jejunal ulcer.

In other cases of jejunal ulcer following gastrojejunostomy, we feel that one of the following operative procedures may solve the problem: (1) Disconnection of the gastrojejunal anastomosis, resection of the jejunal ulcer, and pyloroplasty or gastroduodenostomy; (2) disconnection of the gastrojejunal anastomosis, excision of the jejunal ulcer, and gastric resection according to the Billroth I method, and (3) gastric resection at the level of the previous gastrojejunal anastomosis with a Pólya type of reconstruction. But, if the jejunal ulcer has followed primary gastric resection of the Billroth II type, it may prove feasible and satisfactory to disconnect the gastrojejunal anastomosis, excise the ulcer, and reconstruct by the Billroth I method.

Although we prefer to carry out one of the more conservative operations whenever possible, in some cases the situation of the jejunal ulcer is such that partial gastrectomy is the only procedure by which the disease can be eliminated. The operation will afford satisfactory relief in a high percentage of cases, but it must be remembered that the mortality will be high because of the poor general condition of patients with jejunal ulcer. The risk of resection of the stomach for peptic ulcer is certainly greater than that entailed in the more conservative procedures. However, resection of the stomach in cases of jejunal ulcer will be attended by only a slightly higher risk than is assumed in carrying out less radical operations, such as excision and reconstruction.

Jejunostomy can also be used to advantage either alone or in conjunction with any of the other procedures, and if the patient's condition is such that an extensive operation is contra-indicated or can be undertaken only at considerable risk, simple jejunostomy may place the upper portion of the gastrointestinal tract at complete rest for a sufficient period to permit the acute

phase of the disease to subside. This added precaution was deemed advisable in 19 of the 597 cases in our study.

The surgical treatment of jejunal ulcer often presents many technical difficulties which entail precise judgment in the selection of the proper procedure and exacting skill in its performance. Consequently, it is impossible to employ a standard technic in all cases. This is well illustrated by the variety of methods utilized in the treatment of the 596 patients with benign lesions (Table VI).

TABLE VI
Type of Operation for Jejunal Ulcer

	Cases	Per Cent
Excision of ulcer and reconstruction of gastrojejunal anastomosis..	59	9.9
Disconnection of old gastrojejunal anastomosis and making a new one.....	44	7.4
Excision of ulcer and disconnection of gastrojejunal anastomosis...	152	25.5
Pyloroplasty and disconnection of gastrojejunal anastomosis.....	118	19.8
Billroth I and disconnection of gastrojejunal anastomosis.....	4	0.7
Posterior Pólya and disconnection of gastrojejunal anastomosis....	167	28.0
Anterior Pólya and disconnection of gastrojejunal anastomosis; entero-anastomosis.....	33	5.5
Anterior Billroth II, with entero-anastomosis.....	6	1.0
Resection, and new anterior or posterior Pólya.....	7	1.2
Closure of perforated jejunal ulcer.....	4	0.7
Jejunostomy alone.....	2	0.3
Total.....	596*	100.0

* Case of carcinoma of stomach not included.

A person who develops a jejunal ulcer should always be considered as having a definite ulcer forming potentiality, and he should not be dismissed by his physician until more is known about the etiology of primary and secondary ulcer. We routinely advise those under our care to return promptly for consultation if any gastro-intestinal difficulty arises. This plan offers the best opportunity to avoid further serious complications. A well directed course of treatment will often effect a cure.

COMMENT

Satisfactory results are usually obtained in cases in which the proper operation has been performed for chronic gastric and duodenal ulcer. There is considerable variation in the statistics regarding the results of surgical treatment. This is the outcome of having no standard by which the judgment and skill of the different individuals can be measured. Occasionally, failure to obtain complete relief following operation on the stomach or duodenum may be due purely to functional disorders. However, before such

a conclusion is justified, the possibility of mechanical or organic factors must be entirely eliminated.

When jejunal ulcer is known to exist, anyone who persists in treating the lesion by medical management for a prolonged period assumes a great responsibility in view of the complications that may develop. The results of treatment of the 597 patients comprising this study illustrate the value of surgical measures in cases of jejunal ulcer, for secondary procedures were required in only 6 per cent of the traced cases.

The development of a jejunal ulcer suggests that the patient probably will not show a greater degree of toleration to another anastomosis between the stomach and jejunum, therefore a radical change in the gastro-intestinal relationship is indicated and, when this is established, it must maintain the normal continuity as nearly as possible. Undoubtedly the Billroth I operation will be used more often in the future as it really offers the ideal solution to the problem. It may be difficult to perform in some cases in which a considerable portion of the stomach has been removed at the primary operation; however, if the procedure can be employed, the continuity of the gastro-intestinal tract will be established in a better way than it would be by a Pólya operation.

SUMMARY

The incidence of jejunal ulcer following gastrojejunostomy for duodenal ulcer is about 2.8 per cent. It might be said that statistical data will not show the true incidence of jejunal ulcer, for figures are based on the patients who underwent the primary operation for peptic ulcer at the clinic and have returned later with jejunal ulcers. However, if cases which could not be traced were included in the series studied, there would be very little change in the percentages, for there are comparatively few patients who have not reported to us when symptoms of jejunal ulcer developed.

In only one case in this series was a jejunal ulcer found subsequent to a gastro-intestinal anastomosis made on account of a malignant lesion in the stomach. In this case the primary operation was a gastric resection.

The highest incidence of jejunal ulcer occurs during the third and fourth decades of life. The ratio of males to females in our series was 12.9 to 1.

Although jejunal ulcer occurs less frequently after partial gastrectomy, the operative mortality in such a procedure, when used routinely, will more than offset the increased liability to recurrent ulceration after conservative operations.

In approximately 50 per cent of the cases, symptoms of jejunal ulcer occurred within one year after the primary operation. The longest period elapsing between the primary operation and the return of symptoms was 19 years.

The characteristics of jejunal ulcer are quite similar to those of peptic ulcer. The tendency toward perforation is quite common, for it was mani-

fest in 43 per cent of the series of 597 cases. Gastrojejunocolic fistula was present in 8.7 per cent of the cases.

Medical management of jejunal ulcer should be undertaken only when there is an opportunity to begin treatment while the lesion is in an early stage. Not infrequently a carefully supervised regimen will not only keep the patient comfortable, but it will eventually permit him to gain control of the condition.

The logical surgical treatment of jejunal ulcer is to take down the gastro-jejunal anastomosis and restore normal gastro-intestinal continuity. If necessary, this procedure may be combined with some form of local operation on the duodenum and pylorus. However, in some cases partial gastrectomy may be indicated.

Only 6 per cent of the 597 patients traced required a secondary operation for jejunal ulcer, regardless of the variations in the nature and extent of the primary surgical treatment of the jejunal lesion.

Finally, a person in whom jejunal ulcer develops very likely has a high ulcer-potentiality, and it should be emphasized that an important part of the treatment is to advise the patient to adhere to a regulated diet indefinitely and to return at intervals for a review of his condition.

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CARCINOMA OF THE JEJUNUM*

REPORT OF THREE CASES

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A SURGICAL review of the treatment of carcinoma of the jejunum is justified by the type of high intestinal obstruction encountered in such cases. Clark, in 1926, found that an early diagnosis of carcinoma of the small intestine had not been made in any of the cases reported up to that time. A review of 30 case reports of carcinoma of the jejunum in the past eight years shows that 72 per cent of the growths have caused an obstruction in the first 12 inches of the jejunum (Fig. 1). An obstructing growth in this region has been successfully treated by the method of resection and anastomosis to be described.

The material for this paper consists of the reports on three cases, operated on respectively by Drs. Edward Peterson, Thomas H. Russell and the author. The case reports of 30 cases that have appeared in the literature since 1927 when Hellstrom brought the subject up to date have been studied as a whole, as have those of Rankin and Raiford.

Occurrence of Small Intestinal Tumors.—Malignant tumors of the small intestine according to Ewing comprise approximately 3 per cent of all of those occurring in the gastro-intestinal tract. In 1932 Raiford collected from the literature 339 tumors of the small intestine and reported 88 cases in 56,500 surgical and autopsy specimens from the Johns Hopkins Hospital, the malignant tumors included three surgical cases of jejunal carcinoma. Bland Sutton in 1914 called attention to the frequent occurrence of tumors in the proximal jejunum and distal ileum. The report of 70 surgical cases of jejunal and ileal carcinoma collected from the literature by Hellstrom in 1927 gives the tumors in the jejunum less frequently than in the ileum. Rankin found a surprising number of jejunal cases to be near the ligament of Treitz in a report of 55 cases of small intestinal tumors from the Mayo Clinic, of which 21 were in the jejunum and 14 in the ileum. The relative percentage of malignant jejunal tumors is approximately 1 per cent of all of those occurring in the gastro-intestinal tract.

Pathology.—The types of growth, from the surgical viewpoint, are two: The majority are annular constricting adenocarcinomata that resemble growths of the sigmoid; and the polypoid tumors that grow into the lumen of the gut and frequently cause an intussusception, the polypoid type were encountered twice in the last 30 case reports. Secondary growths from other regions are mainly from carcinoma of the ovary and involvement by extension from the stomach and colon. In 75 per cent enlarged mesenteric nodes were present

* Read before the New York Surgical Society, April 10, 1935.

at the time of operation. A further enlargement of the retroperitoneal nodes at the origin of the superior mesenteric artery does not necessarily mean malignant extension nor do they preclude the advisability of radical resection as the nodes may be inflammatory. Perforation of the growth with peritonitis has been reported in one surgical instance since 1927, and autopsy reports of this complication are unusual.

Symptoms and Diagnosis.—There are no specific symptoms of cancer in the jejunum. In the early stage of the growth there are usually no subjective symptoms other than anemia and asthenia. The annular type of growth produces symptoms of increasing intestinal occlusion with repeated attacks of vomiting of an obstructive type. In the case reports of the last 40 cases

the majority were operated upon with symptoms of from four to six months' duration. In the annular type the symptoms varied from one month to three years and four cases were operated upon in an attack of acute intestinal obstruction. In the series of 21 cases from the Mayo Clinic the average duration of symptoms was 14 to 15 months. The polypoid growths with acute intussusception and acute obstruction occur more often in the lower jejunum and ileum.

Vomiting is the most characteristic symptom and it was present in 28 of 30 cases reported since 1927. The vomiting of large amounts of grayish green liquid containing particles of undigested food is typical for obstruction near the ligament of Treitz. The character of the vomitus

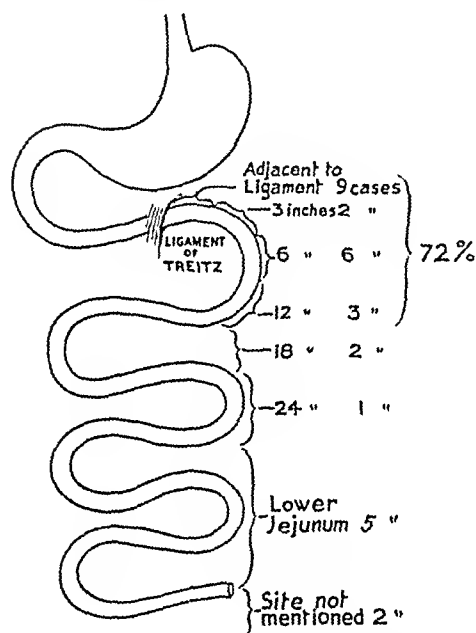


FIG. 1.—A schematic representation of the location of growths in the last 30 case reports appearing in the literature.

is misleading in that it does not resemble fecal vomiting and therefore the severity of the obstruction may not be suspected from this symptom alone as would be the case in fecal vomiting.

Pain is not a symptom of frequent occurrence in the case reports of growths at or near the ligament of Treitz. Distention of the duodenum and first portion of the jejunum occurs without producing the characteristic colicky pain complained of in obstruction from growth in the ileum and colon. Epigastric distress from distention is relieved by vomiting and in one instance induced vomiting to relieve distress has been reported. Steady pain in the epigastrium is a late symptom and probably results from metastasis to retroperitoneal nodes. Penetration by the growths is rare and there has been no case report found giving the type of pain that occurs in gastrojejunal ulcer.

Visible peristalsis has been reported to be present only when the growth was present in the lower jejunum. Objective abdominal distention is absent or not noticeable in growths in the proximal jejunum. Obstipation and

gradually increasing constipation have been emphasized by writers on the subject of cancer of the small bowel but they are not so frequently reported in cases of growths in the jejunum.

Loss of weight is a striking symptom and amounts varying from five to 40 pounds are reported. . This was an important finding noted in 28 of the last 30 cases reported.

Annular growths in the jejunum do not usually pass through an ulcerating stage so that hemorrhage is rarely encountered; one instance was reported in 30 cases. As the polypoid growths tend to grow into the lumen of the gut, a large mass rarely forms before obstruction occurs and the palpation of an abdominal mass is usually not possible until after metastasis takes place.

The roentgenographic diagnosis of carcinoma of the jejunum depends upon the presence of obstruction. This portion of the intestinal tract does not lend itself to roentgenographic study as does the pylorus and duodenum. In 30 case reports a roentgenogram was taken in 23 with the diagnosis of obstruction in the jejunum in 19, a duodenal ulcer in one and as negative in three. The roentgenograms in Case I (Fig. 2), are typical of those appearing in various case reports as characteristic for obstruction of the jejunum by cancer. No case report has been found in which

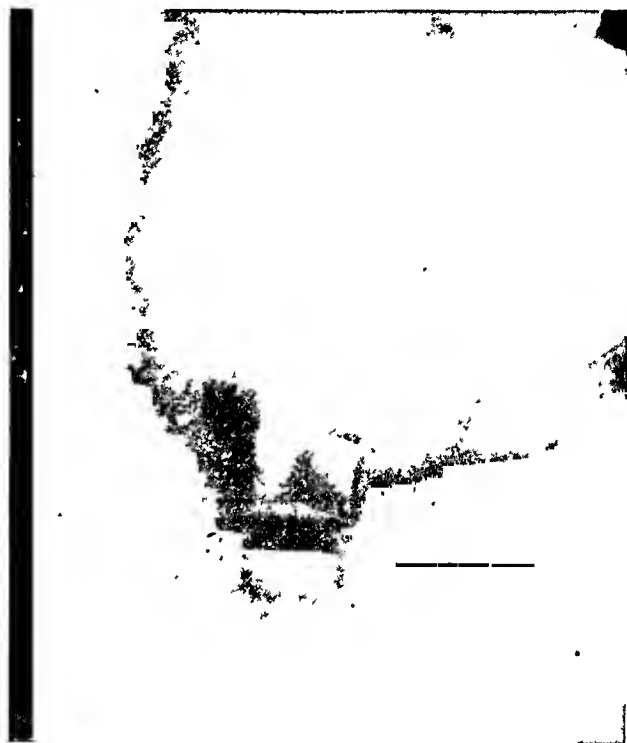


FIG. 2.—Case I: Roentgenogram showing obstruction in the first portion of the jejunum.

roentgenographic diagnosis of cancer of the jejunum was made before obstruction took place. An improved technic for the roentgenographic study of the jejunum seems to offer the only chance for an early diagnosis of tumors in this region.

Treatment.—Every phase of the subject has been adequately treated in the literature by Raiford, Rankin, Clark, Hellstrom and Hinz except that of treatment. The usual short paragraph devoted to treatment recommends excision where possible with an end-to-end or side-to-side anastomosis depending upon the condition found at the time of operation. If inoperable, sidetracking operations are advised. No well-devised plan has been advocated for the treatment of these cases of obstruction.

As patients with jejunal occlusion by cancer are gradually subjected to intestinal obstruction, they become accustomed to the changes in metabolism. A somewhat similar condition in hypertrophic stenosis of the pylorus has shown the value of adequate preoperative preparation in the lowering of opera-

tive mortality. It is just as important to adequately prepare patients with obstruction in the jejunum, and sufficient time for this preparation should be taken in all except the cases of perforation with peritonitis.

A chemical blood determination of the urea, sugar, chlorides and CO_2 combining power is important in determining the extent of alkalosis in these patients. The preoperative administration of 3,000 to 4,000 cc. of fluid with 400 Gm. of glucose and 30 to 40 Gm. of sodium chloride is indicated in every case of high intestinal obstruction that does not show signs of sepsis by a high fever, pulse or other signs of shock. In severe or protracted cases two or three days of medical treatment are permissible and advisable rather than emergency operation.

Frequent lavage or continuous intubation with the Levine tube during the preoperative period is an advantage in draining the proximal segment of duodenum and jejunum. A safe rule to follow would be to prepare for operation all patients with an inanition temperature by a daily routine of intravenous or subcutaneous administration of fluid, glucose and chloride, until the temperature does not rise above 100°F .

General anesthesia with ether is preferable for complete relaxation and it will be well borne by patients who have had adequate preoperative preparation.

Operative Procedure.—Resection of the growth and removal of metastases should be the aim in operating upon these patients. As in carcinoma of the sigmoid, the growths in the jejunum tend to metastasize to regional lymph nodes and distant metastases are late in occurring. Inoperable retroperitoneal lymph nodes should not be taken as a sign of inoperability as they may be inflammatory and a sidetracking operation entails about the same amount of surgery as removal and anastomosis.

At the ligament of Treitz and within 12 inches below there arises the necessity for particular consideration in performing an anastomosis after excision of the segment of the gut containing the growth. The edema, hypertrophy and dilatation of the gut proximal to the growth make an end-to-end anastomosis in this region difficult. The disproportion in the caliber of the two segments, rapid peristalsis in this region and the danger of leakage of the suture line. Under these conditions a side-to-side union is the operation of choice. Due to the proximity of the ligament of Treitz there may not be sufficient jejunum below this point after excision of the tumor to allow for a side-to-side anastomosis.

During the resection of the growth in Case I Dr. Thomas H. Russell advised that an end-to-end anastomosis by him under similar conditions in two cases had been followed by leakage with peritonitis and death. In casting around for another method the bulging of the third portion of the duodenum to the right of the ligament of Treitz was noted (Fig. 3). Following Doctor Russell's advice the end-to-end anastomosis method was discarded and duodenojejunojejunostomy was decided upon. The proximal jejunum was inverted

and buried very similar to the method in common use for the duodenum in the Pólya partial gastrectomy. The anterior leaf of the transverse mesocolon



FIG. 3.—Appearance of growth and dilated jejunum and duodenum in Case I.



FIG. 4.—Resection of the portion of the jejunum containing the growth and opening in transverse mesocolon. The wall of the duodenum was drawn through the slit (Fig. 5).

was incised as for a gastrojejunostomy (Fig. 4). The distal jejunum was swung to the right, contraclockwise, to lie by the distended duodenum. A



FIG. 5.—Duodenum drawn through and prepared for anastomosis.



FIG. 6.—Anastomosis between the distal jejunum and third portion of duodenum.

side-to-side anastomosis was performed in the usual manner. The upper edge of the slit in the mesocolon was sewn to the duodenum anteriorly. The

mesentery of the distal jejunum along its cut border was stitched to the peritoneum of the posterior abdominal wall (Fig. 6).

The previous operations reported in the literature as being used for growths in this region have been gastro-enterostomy by Bevan who reported that the patient recovered and remained comfortable so long as the stomach was washed thoroughly every day. An end-to-end anastomosis by various authors has been used with a high mortality. An end-to-side, duodenum to jejunum, by Lundberg who reports a successful case with the method. Resection of the growth at the ligament of Treitz with a gastro-enterostomy performed with the distal segment necessitates the regurgitation of the bile and pancreatic juice into the stomach. This reverse peristalsis is sufficient

to cause nausea or a distinct discomfort to the patient.

For patients with inoperable growths in this region the operation as recommended by Rankin of duodenojejunostomy is recommended.

Immediately following the anastomosis a Levine tube should be introduced from the stomach into the jejunum. This will insure drainage of the duodenum into the jejunum.

The postoperative behavior of the blind end of the jejunum in Case I, shows that this segment together with the duodenum has returned to normal caliber and, while a small amount of barium is seen in the blind end, the major portion of the meal finds its



FIG. 7.—Appearance of roentgenogram in Case I one year following operation.

way through the new opening. There is some evidence in the picture of lakeing at the site of anastomosis which has caused no subjective symptoms so far (Fig. 7).

The report of the successful outcome in a method employed on one occasion would not be justified under different conditions. The method described is reported at this time because of the rare occurrence of growths in this region and, while a similar use of this method has not been found in the literature, the basic principle of the anastomosis has been shown to be sound when used for other more common conditions.

Prognosis.—In the 70 cases studied by Hellstrom there were 47 cases of resection with a primary mortality of 43.5 per cent. Thus radical resection was possible in 67 per cent of cases with an operative mortality of 36.2 per cent. The follow up results in the cases in Hellstrom's series shows a definite cure in 16 per cent. In Rankin's report of 21 cases from the Mayo Clinic the prognosis was poor regardless of the surgical procedure, no patient lived

longer than three years after operation and the average was less than one year. In the reports of 30 cases since 1927, exclusive of Rankin's and Raiford's series, there have been 24 cases of radical resection, or 80 per cent, and six cases with inoperable conditions for which side tracking operations were performed in five and an abdominal exploration in one. Of the 24 cases of radical resection 16 recovered from operation with an operative mortality of 43.4 per cent. The method of end-to-end anastomosis resulted in recovery in nine cases and death in six. The six cases with side-to-side anastomosis all recovered. In four cases in which the type of anastomosis after resection was not specified there were two deaths and two recoveries.

The follow up record of the 30 case reports is incomplete, one case is reported alive and well after five years, one after 26 months, two after one year, one after six months and one death from recurrence after three years.

The experience with the three cases reported at this time is: All had glandular metastases at the time of operation; two were resected with one end-to-end anastomosis and one side-to-side; one inoperable in which a side-to-side union was done with operative recovery and death six weeks later from cachexia. The patient that recovered following radical excision in which the enlarged nodes showed no cancerous involvement, is alive and well 14 months after operation.

CASE REPORTS

CASE I.—E. D., female, white, age 59. Admitted to the Post Graduate Hospital February 23, 1934.

Past History.—Always in good health with the exception of phlebitis of leg 35 years before, following birth of child. Tonsillectomy, seven years previously followed by erysipelis of the face.

Present History.—Chief complaint of intermittent attacks of vomiting for two years accompanied by mild epigastric pain. The attacks have lasted for one to two days and were followed by a period of freedom from all symptoms. Constipation has been chronic. For one week prior to admission vomiting has been continuous. Loss of weight of 12 pounds in last few months.

Physical Examination.—Well nourished and not acutely ill. Abdomen moderately distended with no palpable masses and no visible peristalsis.

Roentgenographic Diagnosis.—Obstruction at fourth portion duodenum (Fig. 2).

Preoperative Diagnosis.—Carcinoma with obstruction of the duodenojejunal region.

Operation.—February 24, 1934. General anesthesia. *Findings.*—Annular carcinoma of the jejunum six inches below the ligament of Treitz with enlargement of the adjacent mesenteric nodes (Fig. 8). Dilatation, edema and hypertrophy of the proximal jejunum.

Procedure.—Resection of the jejunal segment and mesentery with duodenojejunostomy.

Postoperative Course.—Vomiting of large quantities of duodenal content for ten days after which no further vomiting occurred. Patient has gained 20 pounds in weight and has no gastro-intestinal symptoms at present. Roentgenograms taken one year after operation show the anastomosis functioning well with very slight tendency to dilatation and stasis at the point of anastomosis.

CASE II.—M. B. McC., female, white, aged 66. Admitted to St. Francis Hospital, June 4, 1930.

Past History.—Childhood diseases. Hysterectomy for uterine fibroids 16 years previously.

Present History.—Began with a fulness after meals, belching of gas and vomiting of six months' duration. Vomiting after every meal for three months. Loss of 30 pounds of weight. Constipation, severe. No pain.

Physical Examination.—Well nourished with no appearance of weight loss. Abdomen negative for mass, point of tenderness, rigidity or visible peristalsis.

Preoperative Diagnosis.—Pyloric obstruction.

Operation.—June 9, 1930, under spinal anesthesia. *Findings.*—Annular carcinoma of jejunum near the ligament of Treitz with enlargement of nodes of the adjacent mesentery. Marked distention and dilatation of the proximal jejunal segment.

Procedure.—Resection of the jejunum and mesentery with an end-to-end anastomosis. Patient did not react well from operation and death occurred two days later.

Pathologic Report.—Adenocarcinoma.



FIG. 8.—Appearance of growth and resected jejunum with retroperitoneal nodes that were removed.

CASE III.—L. S., male, colored, aged 46. Admitted to the Post Graduate Hospital in July, 1904.

Past History.—All diseases of childhood. Typhoid fever at five years of age, gonorrhea at 21 and possible chancre at 23.

Present History.—Began two years previously with gradual onset and increasing severity of gastric distress of distention with gas which was relieved by vomiting. Distress had enforced irregular eating with a loss of 40 pounds of weight in four months.

Physical Examination.—General appearance of loss of weight with weakness. The abdomen was scaphoid, tense, no masses felt and after taking water gastric peristalsis was visible.

Preoperative Diagnosis.—Pyloric obstruction.

Operation.—July 16, 1904, revealed a distended stomach and duodenum. A narrow fibrous annular stricture of the jejunum, 18 inches below the ligament of Treitz, was found with extensive lymph node enlargement in the adjoining mesentery and a large retroperitoneal mass.

Procedure.—A side-to-side anastomosis was performed by the elastic ligature method. Patient was discharged from the hospital one month later with symptoms of distress relieved. Death occurred six weeks later from cachexia.

Pathologic Report.—A node removed from the mesentery showed adenocarcinoma of the scirrhus type.

CONCLUSIONS

(1) Carcinoma of the jejunum is rare; it represents approximately one per cent of all of the cases of carcinoma that occur in the gastro-intestinal tract.

(2) Approximately 72 per cent of growths occur in the first 12 inches of the jejunum.

(3) Polypoid growths with intussusception are rare in the jejunum.

(4) The diagnosis is dependent upon symptoms and signs of high intestinal obstruction.

(5) Preoperative preparation of the patient is of paramount importance in reducing operative mortality.

(6) Resection of the growth with side-to-side duodenojejunostomy is the procedure of choice in growths in the jejunum in the region of the ligament of Treitz.

DISCUSSION.—DR. PAUL K. SAUER (New York) stated that fortunately carcinoma of the small intestine is an infrequent occurrence, and that its diagnosis was most difficult, being made usually at operation. Not all portions of the intestinal canal are attacked with equal frequency, the incidence being in direct ratio to the distance from the stomach. Nothnagal, reporting on 1,100 cases, showed that only 2.5 per cent of carcinoma of the intestinal canal occurred in the small gut. De Bovis, who gathered the statistics of Maydl, Holsti, and Ruepp, reported 6.3 per cent in the jejunum and ileum; and G. Heimanns found 20 cases among 1,706 examinations of carcinoma of the intestinal canal, about 1.1 per cent.

The type most frequently found is the cylindrical cell adenocarcinoma. The medullary type is less frequent, and the gelatinous and scirrhus types are the least frequent in the order named. Anschütz first called attention to the fact that neoplasms of the small gut show a predilection for the first portion of the jejunum and the terminal portion of the ileum. Kanzler noted that 25 per cent of his cases occurred between the first and third decades.

The character of the vomitus is an important point in evaluating symptoms. If the vomitus is analyzed, free hydrochloric acid is noticeably absent, and the combined acid greatly reduced. Pain is usually absent and appears only very late as the result of metastases, or is due to severe obstruction.

The prognosis is always grave. Albrecht, in 1918, reported eight cases with a mortality of 100 per cent. Hellstrom's mortality is 79.7 per cent. In all probability most of these cases were operated upon as emergencies to relieve the obstruction. In those in which the diagnosis may be suspected, and the preoperative treatment as outlined by Carter carried out, the mortality will be much lowered.

CASE REPORTS

CASE I.—M. B. (No. 27680). Female, aged 51, was admitted to the Lenox Hill Hospital, complaining of weakness and nervousness for six weeks, and of nausea and vomiting for ten months. There had been no pain and no melena. Otherwise the history was not significant. She died on the sixth day after admission without a diagnosis having been made. The autopsy report showed: "A tumor at the duodenojejunal

juncture, polypoid in character, and almost occluding the lumen. The tumor is extensively ulcerated, of fairly soft consistency, deeply infiltrates the wall and encircles the entire lumen. The duodenum is greatly distended. Diagnosis: Carcinoma of the jejunum."

CASE II.—A. W. (No. 40449). Female, aged 37, was admitted to the Lenox Hill Hospital in a semicomatose condition. The history, obtained from her husband, revealed that the patient had not been well for the past two or three years, but the acute symptoms were severe pain in the right upper abdomen and vomiting of small amounts of fluids, which had been present for 12 days. The patient died on the day following admission, no diagnosis having been made. The autopsy report showed an intussusception of the jejunum, which had been reduced. A mass was found 65 cm. from the duodenojejunal junction. It was found to encircle the jejunum. There were numerous papillary growths. The mesenteric nodes were slightly enlarged. Diagnosis: Carcinoma of the jejunum.

DR. THOMAS H. RUSSELL (New York) said that the two cases, mentioned by Doctor Carter in his paper, were both women, both over 60 years of age, both completely obstructed, both had lost between 30 and 40 pounds in weight in the few weeks preceding operation, both presented a growth eight to ten inches from the ligament of Treitz, both showed symptoms of myocarditis before operation, both died a few days after operation, and both were adenocarcinomata completely encircling the jejunum.

When Doctor Russell in consultation with Doctor Carter saw the case since successfully operated on, he mentioned his experience with his own two cases and said that if diagnosis could be made he would operate in stages. However, Doctor Carter had worked out an idea of using preoperative treatment instead of a multiple stage operation, followed by resection of the growth and a side-to-side anastomosis utilizing the duodenum farther up in preference, for reasons of safety, rather than to anastomose to the dilated intestine immediately proximal to the duodenum. In one of his cases, Doctor Russell had resected the growth with an end-to-end anastomosis and jejunostomy proximal to the site of anastomosis. In the other, he had resected the growth with an end-to-end anastomosis and did a gastro-enterostomy, thinking that this might take the place of an enterostomy.

DOCTOR CARTER said that in reviewing all of the cases up to date he had been unable to distinguish well the exact site of the tumor in the earlier reports, but it was his impression that less than 100 cases of surgical carcinoma of the jejunum have been reported, though there were many more autopsy reports. In the latter, the incidence of carcinoma of the jejunum varies from 0 to 9 per cent, with 3 per cent a fair average.

THE SURGICAL DIABETIC

A FIVE YEAR SURVEY

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THE fact that there are doubtless well over a million diabetics in the United States, the incidence of the disease being between one and two per cent of the population, and that, as Joslin says, every other diabetic is a surgical diabetic before he dies, indicates the importance of the consideration of this subject and justifies any effort toward analysis of our hospital work.

Diabetes is a common disease, becoming increasingly more so since the advent of insulin in 1922, paradoxical as such a statement as that seems. When we recall, however, that in the past, before the use of insulin, more than 80 per cent of patients with severe diabetes died within ten years and that children developing diabetes seldom lived more than six, it becomes evident that because of insulin, now promising practically a normal span of life for the diabetic, there are thousands of diabetics among the general population who would long since have died without it and that the more successful our treatment of diabetes becomes, short of any measure which may restore the affected pancreas to its full functional capacity, the greater will be the incidence of the disease.

Not only are more diabetics reaching adult life and more advanced years, but for the same reason more diabetics are constantly becoming surgical diabetics. This is not so much because of the existence of conditions commonly associated with diabetes, as because of the fact that diabetics now more frequently reach an age where surgical conditions common to that age develop. Insulin has made it possible for the diabetic to share with those not so afflicted the ailments common to all men and to all decades of life.

The modern medical mortality in diabetes has through insulin thus been markedly reduced, to as low as 1.7 per cent as reported by Joslin, and even here the deaths are due not to acidosis and coma, but to arteriosclerosis and cardiorenal disease.

It is admitted, however, that with the surgical diabetic, the picture abruptly changes and assumes a far more serious aspect. With a mortality of 11 per cent in a group of Joslin's surgical diabetics, it is at once apparent that the surgical diabetic is the serious diabetic and is six times as likely to die as the diabetic who has no surgical disease. But this mortality rate is one in an institution where the principles of the proper treatment of diabetes have long been recognized and scientifically practiced and by no means

represents the results which may be expected or even uniformly obtained in the average hospital.

With our scientific knowledge of the powers of insulin and the possibilities in the modern management of diabetes, we must nevertheless not be lulled into a sense of complete security, for the mortality rate in the surgical diabetic is still appalling and figures three times as high as Joslin's can readily be found in the literature and sometimes even on our own services.

It is well, therefore, to discount the comforting statements so frequently made that the diabetic is or can be made as fitting a subject for surgery as the nondiabetic and to keep firmly in mind that this is so only when every precaution is taken in the management of these cases. It is far safer still to consider the surgical diabetic essentially a bad surgical risk. The recognition of this fact is the first step in the proper handling of the case and whatever surgery is indicated, it will assure a routine, adequate and workable cooperation between internist and surgeon that will alone properly safeguard him.

Aside from the dangers, inherent in the diabetic, of an unbalanced metabolism, brought on through operation or the coexistence of arteriosclerosis, the lowered resistance to infection and the administration of an anesthetic, are the two important factors which spell defeat for the surgical case. As M. J. Henry states, practically the only way in which the properly controlled diabetic patient differs from the nondiabetic one of similar age and physical condition is in his reaction to the presence of infection. Infection is a disruptive force to the diabetic. Whether this is due to lowered resistance of the sugar-laden tissues with impairment of normal cell proliferation or to a disturbance in metabolism from improper assimilation of carbohydrates, as Minkowski states, or to vascular deficiencies or to any of many other causes, the advent of infection is often quickly disastrous to the diabetic patient. Because of the polyuria and common dehydration with dryness of the skin, infection here can readily occur, as infectious processes can of course develop elsewhere, but having once taken hold, such a process disrupts the metabolic balance, tends to increase acidosis, makes the usual doses of insulin inadequate and unless promptly controlled surgically, can and frequently will prove to be a terminal factor in the disease.

To lose a patient from a cellulitis after he has successfully passed through both stages of a radical resection for carcinoma of the rectum, for instance, impresses one with the rôle that infection can play in the diabetic, but we see it still more frequently, of course, in infections such as carbuncles or in association with gangrene of the extremities, in which infection sweeps through the organism in a rapidly fatal septicaemia. Besides this lowered resistance of the diabetic to infection, therefore, an additional factor which tends to make of the diabetic a poor surgical risk is the coexistence, in one form or another, of arteriosclerosis. It is stated that the diabetic is an arteriosclerotic if he has had the disease over five years and this involves not only the peripheral vessels with consequent impairment of circulation and increased susceptibility to gangrene, but the cerebral and coronary

vessels as well. Many a diabetic and practically all gallstone and gangrene cases, Joslin states, have perhaps an unsuspected coronary or cardiorenal disease and according to the extent and character of the underlying pathology, present that much more of a problem in the preoperative and postoperative care.

The surgical diabetic, moreover, is beset by still other difficulties which add to the hazards of operative therapy. Many have been depleted by a recent loss of weight, which in some instances is often marked. McKittrick and Root in 100 surgical diabetics found this to average 54 pounds, which is an obvious indication of the diminished vitality supporting these patients.

The relation of hyperthyroidism to diabetes is of considerable interest, about one per cent of the cases of hyperthyroidism being complicated by the coexistence of diabetes. The dietary control of such a case is obviously difficult, for regardless of the dietary restrictions, the hyperthyroidism causes, as Joslin so succinctly describes it, an "endogenous overeating," which only a thyroidectomy will correct, benefiting, in this way, not only the hyperthyroidism, but frequently the diabetes as well.

With an increased susceptibility to shock, intolerance to infection or trauma, diminished reparative powers, subject to the constant threat of acidosis, suffering from the effects of latent or actual arteriosclerotic changes, often peculiarly depleted from the effects of starvation, diarrhea or vomiting, with all the metabolic processes inordinately affected by fever or hyperthyroidism, the diabetic patient is truly one who presents a complex problem. That such a patient can successfully undergo operative procedures is a triumph for the modern management of these cases, but in spite of the justly confident statements in the literature regarding the possibilities of surgery in the diabetic, it is hazardous to lose sight of the fact that the diabetic is at least potentially a poor surgical risk and that success will be achieved only by an appreciation of the intricacies of the problem and painstaking care in their management.

The question of anesthesia also is of paramount importance in the diabetic but with the splendid development in this field during the past decade, the difficulties here have been largely overcome. Tissue-cell destruction from the toxic effect of anesthetics resulting in impairment of the glycogenic function of the liver must be avoided. For this reason chloroform is definitely contraindicated. Ether likewise causes a hyperglycemia even in normal patients, and moreover greatly inhibits the action of insulin, but with proper precautions is still frequently used with safety. Ethylene, giving greater relaxation than gas and oxygen, has many advocates and in conjunction with local infiltration of the abdominal wall is often ideal. It must be remembered, however, that local infiltration lowers the resistance of the injected tissues, even in normal individuals, particularly in the presence of inflammation. Local infiltration in infected areas should, therefore, be avoided.

Spinal anesthesia in the absence of conditions contraindicating its employment probably has its greatest field of usefulness in the diabetic, but in

the choice of any anesthetic, due consideration should always be given to the underlying complications, the presence or absence of infection, the cardiovascular reserve, as well as to the probable effects upon metabolism itself. Postoperative vomiting and its resulting dehydration and possible acidosis or alkalosis should be avoided.

In discussing the types of surgical conditions met with in diabetics, we find that they are usually considered as falling into two main groups:

(1) Those which are held to be true complications of the disease itself, such as infections of the extremities, cellulitis, carbuncles or gangrene; a group in which the predominating mortality lies.

(2) Those which are merely coincident to the diabetes, having no causal relationship to that disease, but met commonly among all classes of patients, especially in the fifth, sixth and seventh decades of life. Here the mortality parallels more closely that of similar conditions found among nondiabetics.

In our study of the surgical diabetics treated at the Mary Immaculate Hospital during the five year period from 1930 to 1935, however, we found the following classification to be of greater assistance to us as it enabled us more clearly to define the standards of treatment for each group:

(1) Urgent cases, such as acute appendicitis, perforated ulcers or acute intestinal obstruction, which tolerate no delay but demand immediate operation.

(2) Essential cases, such as certain infections, many cases of gangrene and other conditions in which, while a prompt resort to surgery is demanded,

TABLE I
Analysis of Cases

Number of surgical diabetics admitted.....	136
Males.....	47
Females.....	89

Age of patients by decades

Years	Cases
1-9.....	0
10-19.....	1
20-29.....	0
30-39.....	9
40-49.....	17
50-59.....	43
60-69.....	46
70-79.....	19
80-89.....	1

Youngest, 14 years of age; oldest, 80 years of age

Period of Hospitalization

From 1 to 106 days; average, 23.9 days

Number of patients with acidosis on admission.....	44
Total number of deaths.....	37 or 27.2 per cent
Number of patients operated upon.....	108
Deaths in operative cases.....	27 or 25 per cent

operation is not necessarily immediate, but may be deferred for a brief space of time in which some effort may be made to stabilize the patient.

(3) Elective cases, such as most gallbladders or uncomplicated herniae, in which, though surgery is more or less strongly indicated, it is not essential to the immediate preservation of life.

In analyzing this series of cases, we have prepared the following tables which indicate briefly the work covered.

TABLE I indicates the number of surgical diabetics admitted during this period, their ages, period of hospitalization, *etc.*, as well as the general and postoperative mortality.

TABLE II lists the various types of surgical conditions present among these diabetics with the mortality rate in each. This, of course, is of little importance in a small series such as this, except in those cases of carbuncles, infections of extremities and gangrene in which the mortality, as in other series, is so strikingly high.

TABLE II
Surgical Conditions Encountered

	Cases	Deaths	Mortal- ity
Appendicitis	12	2	16.8
Gallbladder disease	5	1	20
Fibroma of uterus	2	0	0
Prostatic hypertrophy	1	1	100
Fractures	13	1	7.7
Perforated peptic ulcers	2	2	100
Herniae	3	0	0
with intestinal obstruction	3	2	66.6
Carbuncles	10	3	30
Infections of extremities	25	5	20
Hyperthyroidism	1	0	0
Empyema	1	0	0
Gangrene	44	20	45.4
Miscellaneous	14	0	0
	<hr/> 136	<hr/> 37	<hr/> 27.2%

TABLE III
Operations Performed

(1) <i>Urgent</i>	Opera- tions	Deaths	Mortal- ity
Appendicitis...	11	2	
Strangulated hernia...	3	2	
Intestinal obstruction (internal)	1	0	
Perforated peptic ulcer...	2	2	
Acute suppurative cholecystitis	1	0	
	<hr/> 18	<hr/> 6	<hr/> 33.3%

	Opera- tions	Deaths	Mortal- ity
(2) <i>Essential</i>			
Ischiorectal abscess.....	1	0	
Fractures and dislocations.....	7	0	
Infections of extremities.....	25	5	
Carbuncles.....	10	3	
Iridectomy (glaucoma).....	1	0	
Suppurative mastitis.....	2	0	
Amputation of leg for gangrene.....	1	0	
Amputation of thigh for gangrene.....	24	12	
Multiple abscesses (septicemia).....	1	1	
	<hr/> 72	<hr/> 21	<hr/> 29.1%
(3) <i>Elective</i>			
Herniac.....	3	0	
Appendicitis (interval).....	3	0	
Submucous resection.....	1	0	
Cataract.....	1	0	
Hemorrhoidectomy.....	1	0	
Tonsillectomy.....	1	0	
Cholecystectomy.....	1	0	
Retroversion and perineal repair.....	2	0	
Endometritis (D. and C.).....	1	0	
Cervical polyp.....	1	0	
Hysterectomy.....	2	0	
Thyroidectomy (hyperthyroidism).....	1	0	
	<hr/> 18	<hr/> 0	<hr/> 0
Total operations.....	108	27	25%

In TABLE III we have presented those cases in which operations were performed. There were 108 patients among the 136 admissions who were operated upon. The mortality is seen to be greatest, of course, among the urgent cases, due to the nature of the surgical conditions present, but is also formidable in the "essential" group in which operation, while not immediate, was usually promptly done with only slight delay for a brief period of preparation. The mortality here was made up almost exclusively among carbuncles, infections and thigh amputations for gangrene, being 30, 20 and 50 per cent, respectively, showing the toll that those types of cases exact. Among the elective group, there was no mortality, although one patient who had had a hysterectomy later entered the hospital with gangrene of an extremity and died following the amputation of the thigh.

In studying the causes of death as shown in TABLE V, it was found that sepsis, and next in importance, arteriosclerotic heart disease, were responsible in the vast majority of cases. It is apparent, therefore, that excluding the surgical conditions which in themselves proved fatal, even in the acute cases, it was not the diabetes itself which killed these patients, but rather the complications of diabetes—lowered resistance to infection and arteriosclerotic changes—which made it impossible for them to respond successfully to the usual surgical measures.

THE SURGICAL DIABETIC

TABLE IV
Anesthetics

	Cases	Deaths
Gas-oxygen.....	36	8
Gas-oxygen-ether.....	15	1
Ethylene.....	21	5
Spinal.....	24	10
Avertine.....	2	0
Local.....	7	1
Local-gas-oxygen.....	1	1
	<hr/> 106	<hr/> 26

In two patients, no anesthetic was employed, the operative procedure in one being the reduction of a dislocation under morphine; the other, with a fatal outcome, being multiple incisions in a case of sepsis.

TABLE V
Analysis of Deaths

<i>Total Number of Deaths...</i>	37 or 27.2%
Died without operation.....	11
Postoperative deaths.....	26

Diagnosis in Fatal Cases

Appendicitis.....	2
Cholecystitis (no operation).....	1
Prostatic hypertrophy.....	1
Fracture of femur (no operation).....	1
Perforated peptic ulcer.....	2
Hernia (strangulated).....	2
Carbuncles.....	3
Infections.....	5
Gangrene (no operation).....	8
Gangrene (with amputation of thigh).....	12
	<hr/>
	37

Causes of Death

Sepsis.....	19
Arteriosclerotic heart disease.....	14
Pneumonia.....	3
Coma.....	1
	<hr/>
	37

Only one patient died from acidosis, that patient entering the hospital unconscious and dying two hours after admission.

The cases of gangrene are indeed a serious problem. It is easy to excuse a fatality in any individual case, for each case presents so many factors which make surgery hazardous, but when one contemplates the results in the aggregate, in a series of cases, such as that analyzed in this five year survey, he cannot fail to be deeply impressed by the fatalities which occur and to be moved by the desire to prevent them.

TABLE VI
Gangrene Cases

<i>Patients Admitted with Gangrene</i>	44
Recoveries.....	21
Signed release (no operation).....	3
Total deaths.....	20 or 45.4%
Died without operation, 8; postoperative deaths, 12	
<i>Spontaneous Recoveries</i>	3
(1) Gangrene of terminal portion of great toe (no operation)	
(2) Gangrene of heel (no operation)	
(3) Gangrene of middle toe (spontaneous amputation with healing)	
<i>Amputations</i>	25
Amputation of leg.....	1
Amputation of thigh.....	24
Five of these patients had preliminary toe amputations. All five required subsequent amputations at higher levels, with recovery.	
Deaths in thigh amputations.....	12 or 50%

Anesthetics in Amputations of Thigh

<i>Anesthetics</i>	Total	Recov- eries	Deaths
Gas-oxygen.....	7	3	4
Gas-oxygen-ether.....	2	1	1
Ethylene.....	7	5	2
Spinal.....	8	3	5
	—	—	—
	24	12	12

Of all the patients admitted in this group, 45 per cent died; of all the thigh amputations, only one in every two survived, the mortality here being exactly 50 per cent. Such a mortality is certainly a challenging one and can be reduced, we believe, only by adherence to the following points:

(1) An earlier resort to surgery in cases demanding operation.

(2) No surgery at all unless it be radical surgery. Preliminary toe amputations or other minor procedures mean secondary amputations at a higher level with a progressively diminishing chance of survival.

(3) Close observation in the cases of dry gangrene, without infection, taking every precaution to avoid infection, while preliminary measures, medical and diagnostic, are carried out to determine the procedure to be followed and if amputation proves necessary, the level at which this can be successfully accomplished. Only in the occasional case, we believe, can this be done below the knee.

(4) Prompt, radical amputation through the thigh in cases of the moist type or with infection, avoiding drainage wherever possible, with the strictest attention to the minutiae of good surgery and staking everything upon securing of primary union in the stump. In the fulminating case, overburdened with toxemia from the infected, gangrenous limb, a guillotine amputation be-

low the knee, as McKittrick suggests, leaving the wound wide open, may give the patient his only chance to strike a balance before a secondary amputation through the thigh could be borne.

(5) The scrupulous avoidance of a tourniquet for gangrene of any type.

(6) Impartial selection of the anesthetic best suited to the individual case.

When we consider the management of the surgical diabetic, there should be no question as to where such a patient belongs. At our hospital, he is admitted on the diabetic service, regardless of the type of complication, and if the complication be eye, ear, nose or throat, urologic, abdominal, pelvic or of the extremity, the attending surgeon on the particular service is called in consultation. It is a recognized fact that under ordinary conditions, surgical delay is harmful; in diabetes it is disastrous. Medical treatment today is flexible and therefore the surgical condition dictates the type of treatment. Medical treatment can and must be adjusted to any type of surgical necessity.

Our system of treatment is based on certain well recognized fundamental principles:

(1) Infection makes the diabetes worse and therefore surgical removal of the focus of infection as soon as it is rationally possible is the best medical treatment we can give the patient.

(2) Treatment for the operation is our first consideration.

(3) We attempt to make the patient as good a surgical risk as is possible.

(4) Because delay is so harmful, the qualified surgeon is our referee as to the need for operation.

(5) The qualified physician prepares the patient and adjusts his dietary regimen to the surgical requirements.

Thus, to sum up, the rule to remember is that when we are treating a diabetic, we are treating a manifestly complex problem. Complications in diabetes prove disastrous, making the diabetes markedly worse, therefore, we must not waste time trying to make the diabetic sugar free because if at all accomplished, it is done at the expense of a great deal of body tissue and huge doses of insulin. We must vigorously attack the complications, thus lessening the severity of the diabetes, after which, simple regulation is all that is necessary. In our management of the various types of surgical procedures as we have grouped them, we carry out the following measures:

Elective Cases.—(1) In these cases we attempt to rid the patient of sugar and acetone.

(2) Our dietary program assures the patient a goodly intake of COH, ranging from 100 Gm. to 150 Gm., depending on the condition and state of nutrition. Thus a goodly amount of glycogen is stored in the liver. Insulin makes this a matter of ease. In total calories, however, the diet is slightly undernourishing. The high COH, low fat program, is the basis of the diabetic treatment at our hospital. In cases with general arteriosclerosis and arteriosclerotic heart disease, the heart and circulation are carefully watched and the blood sugar is never permitted to fall suddenly. Insulin

is used conservatively, for while our objective is diabetic control, it is dangerous to cause violent fluctuations in the blood sugar level because of the accidents which may occur in the heart and arteries.

(3) As the day of operation approaches, fat and then protein are omitted and 24 hours prior to operation, the diet consists of easily digested and absorbed COH only, plus fluids, salt and insulin.

(4) The patient is never starved prior to operation. He receives insulin, a COH breakfast by mouth or, in equivalent glucose in saline, intravenously, and two and one-half hours later goes to the operating room. The operation does not alter the established dietary routine of the diabetic at all. Following operation, he receives his luncheon COH in equivalent glucose in saline intravenously and his regulated dose of insulin follows. His supper, depending on conditions, is taken by mouth or is repeated intravenously as at lunch, again followed by insulin. We like the early and late method of the administration of insulin and use it a great deal. Included in this program are clyses, salt solution and tap water by rectum as indicated.

(5) On the day following operation, food is given by mouth and then the patient's program is reestablished with later additions of protein and fat. We have not found it necessary to do frequent blood sugar determinations for guidance in our program. The blood sugar is made relatively normal on the morning of operation and since operation does not alter the established program, frequent postoperative blood sugars are not indicated. The patient is eventually reregulated during his convalescent period. It is during this period that careful watch is maintained because the insulin requirement may change. Here blood sugar determinations are important in the guidance of the program. We have not had to be worried about postoperative hypoglycemia under this régime. Routine T.I.D. urines for sugar and acetone are done right on the floor by the nursing staff, who are carefully trained in the care and treatment of diabetics. All findings are charted on a special diabetic record sheet so that we know at all times just what is happening. Both the surgeon and the medical man take care of their respective duties and a condition of perfect cooperative harmony exists to the ultimate benefit of the patient. This routine is followed with indicated changes for diabetic obstetric cases as well.

Essential Cases.—The patient here is regulated to a COH and fluid intake only. Protein and fat are not included in his diet. While this patient may not be in urgent need of surgery, yet speed in his preparation may be necessary so that when after 24 to 48 hours operation may be deemed indicated, he will enter the operating room in good condition and well prepared. After operation his course proceeds as with the elective case.

Urgent Cases.—No attempt can be made to rid the urine of sugar and acetone in these cases. The patient receives a single dose of from 20 to 30 units of insulin and from 500 to 1,000 cc. of saline intravenously. Insulin, glucose and fluids here are given as indicated. There is no set rule as to the procedure in this type of patient. Every case is a distinct individual

problem and can be treated only as indications warrant. The patient is then operated upon. From this point, the case is then considered as one of acidosis and treated with all the details that the treatment of a case of diabetic acidosis entails.

In this survey of surgical diabetics at the Mary Immaculate Hospital, therefore, we have attempted:

(1) To review the difficulties which should be kept in mind in the surgical care of these patients with due emphasis upon the mortality which ordinarily accompanies the development of complications of this disease.

(2) To present an analysis of the conditions encountered at our hospital, with the operative work and results obtained.

(3) To discuss the measures which are followed in the general management of these cases.

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INTESTINAL OBSTRUCTION

EVALUATION OF THE ROENTGEN DIAGNOSIS

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✓ REVIEWING the literature pertaining to the roentgen diagnosis of intestinal obstruction, one is likely to obtain the impression that the radiograph serves as a very simple and never failing means by which this condition can be diagnosed; a postero-anterior exposure, preferably with the patient in the vertical posture, without the aid of an opaque media appears to be the only requisite. The finding of gas within the small intestine on this film, according to some, suffices for a diagnosis of obstruction in patients over two years of age; in addition, evidence of fluid in the small intestine adds further but unnecessary proof. The object of the presentation of the analysis of this series is to point out that while the roentgenogram is very helpful in determining the presence and site of intestinal obstruction, the diagnosis is at times very difficult and occasionally definite conclusions cannot be drawn from a single roentgen examination.

Schwartz¹ reported on the roentgen ray examination of the abdomen without the use of opaque media in 1911. Since that time Assmann,² Case,³ Bensaude and Guénaux⁴ and many others have contributed to our knowledge of the subject. Briefly, practically all agree that the presence of distended loops of bowel, particularly with intra-intestinal fluid levels, is indicative of obstruction. Many are of the opinion that any gas in the small intestine in patients over two years of age is abnormal and should be considered the result of obstruction. Kalbfleisch,⁶ in 1927, stated that distended loops of bowel may be considered pathognomonic of intestinal obstruction and the presence of even one fluid level is confirmatory evidence.

As to the time of appearance of these radiographic findings, Case³ reported in 1928 that gas and fluid began to accumulate within six to eight hours after obstruction had been established. The time interval for experimental visualization reported by Wagensteen and Lynch⁷ was four or five hours after simple obstruction of the small intestine had been established; they added that in obstruction with strangulation, gas accumulated later and in smaller amount. In 1933, Ochsner,^{5,9} from an experimental study, deduced that the lower the obstruction the greater is the amount of gas and fluid accumulation, and that these features were more marked in strangulated than in simple obstruction; he also mentioned that in both simple and strangulated obstruction of the ileum the amount of gas present one hour after the production

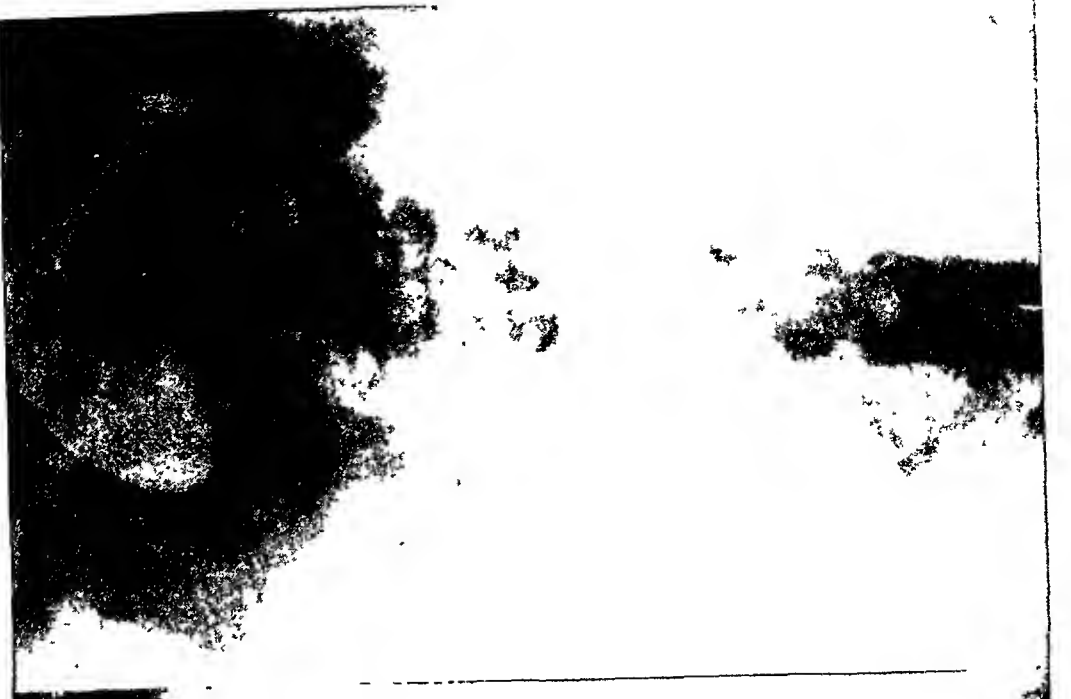


Fig. 1 (Case I).—This and the succeeding two figures demonstrate the progression of a distal ileal obstruction made possible by the patient's refusal to consent to early operation. The above figure represents the findings 22 hours after onset of illness and demonstrates the dilatation of the small bowel well above the point of obstruction.



Fig. 2 (Case I).—Forty-five hours after onset of illness, shows more marked and extensive gaseous distention and absence of fluid.

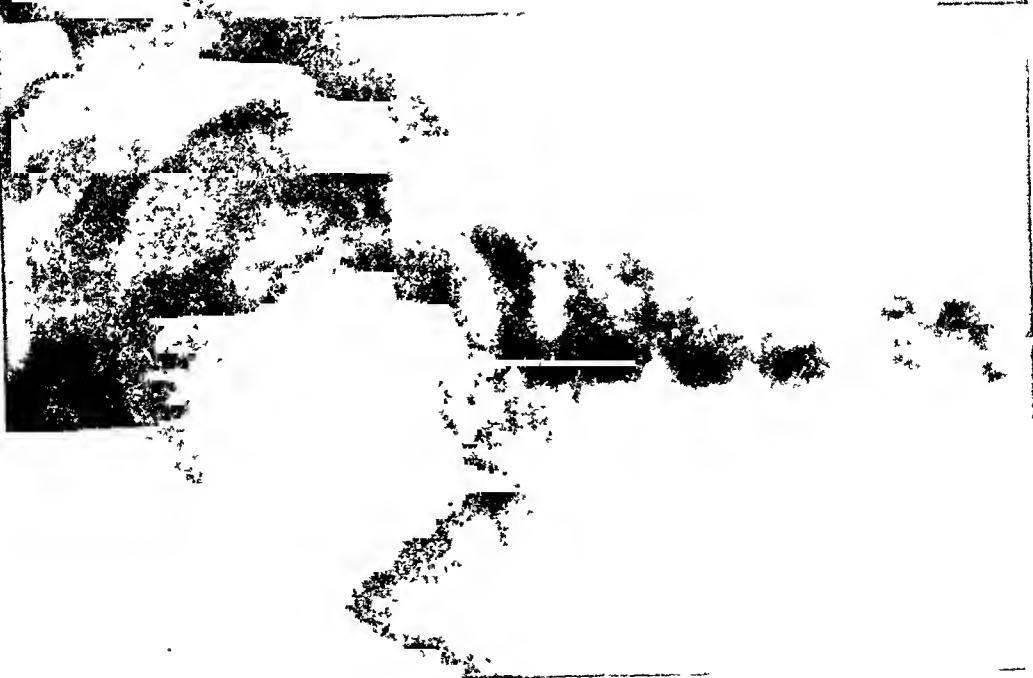


Fig. 3 (Case I).—Demonstrates fluid levels but less gaseous distention 133 hours after onset of illness.

of the obstruction permitted a positive roentgen ray diagnosis, and with simple jejunal obstruction as early as three hours.

Intra-intestinal gas is associated with the paralytic as well as the mechanical form of obstruction. In the latter type, exemplified by the chronic obstruction, according to Boyd,¹⁰ stenosis occurs gradually with resulting dilatation and hypertrophy above. When complete, paresis and degeneration of the musculature occurs proximal to the obstruction; gases formed from the accumulated contents contribute to the dilatation. In the acute paralysis, frequently the result of general or localized adhesive peritonitis, stagnation of contents with gas formation also occurs. In strangulation the accumulation of gas is also due to the interference of the usual gaseous exchange. The



FIG. 4 (Case II).—Ileal obstruction demonstrating the position and configuration of the bowel with fluid levels as presented in the transabdominal exposure.

intra-intestinal fluid noted above the point of obstruction results from the hyperactive irritated intestinal glands, the inflammatory exudate and the non-absorbed ingested fluids.

The gas-containing intestine may be identified by its contour and position. The irregularity of outline of the small intestine resulting from the valvulae conniventes may be noted beyond the first portion of the duodenum through the jejunum and in the proximal portion of the ileum. These mucosal folds present on the radiograph what has been referred to as the herringbone appearance. On marked distention these plications viewed obliquely present an elliptical appearance and may be confused with the haustration of the large intestine; the intervals of indenture of contour are greater in the

DIAGNOSIS OF INTESTINAL OBSTRUCTION



FIG. 5 (Case T54).—Intestinal obstruction occurring two weeks after appendectomy, showing localized distention of the jejunum. Note similarity of Fig. 11 of nonobstructive distention.



FIG. 6 (Case T51).—Ileal distention with fluid levels in a patient two months postappendectomy.



FIG. 7 (Case T51).—Radiograph after three-hour interval. Localized ileal distention now absent. Symptoms subsided. (No operation.) Probably indicative of a transient ileal obstruction.



FIG. 8 (Case VII).—Rectosigmoid obstruction resulting from carcinoma of this area. Shows marked dilatation of the colon with no fluid levels and also dilatation of the upper ileal loops apparently the result of small intestinal fixation in the mass.

FIG 9 (Case T55).—Carcinoma of cecum with metastasis to liver demonstrating extensive small intestinal dilatation

FIG. 10 (Case T56).—Nonobstructed case Clinical diagnosis of chronic nephritis Shows localized small intestinal dilatation as frequently noted in the debilitated patient

FIG 11 (Case T57).—Nonobstructed case demonstrating dilated parallel loops of small intestine noted during the course of a urologic work-up Note small intestinal distention somewhat similar to Fig. 5 Some large intestinal gas present in this case

FIG 12 (Case T60).—Nonobstructed case demonstrating fluid levels and dilatation of both small and large intestines after enema and catharsis

colon. On account of the relationship of the small intestinal coils there is produced the familiar stepladder effect in the presence of air and fluid. The jejunal loops are more commonly found above and to the left of the midline, and the ileum below and to the right. The colon may be distinguished by its haustration, as well as by its larger caliber. The maximum distention of the colon was found to be 12 cm., while that of the small intestine was 5.8 cm. (film measurement corrected for distortion). On marked distention the characteristic irregularities of contour may be effaced and the gut displaced from its usual position rendering a decision as to the exact segment involved very difficult if not at times impossible.

For radiographic examination of the obstruction suspect the vertical or semivertical posture serves most satisfactorily; this position is best obtained with the aid of the tilt-type table. In the absence of such special apparatus, the transabdominal exposure may be used to obviate any inconvenience to the weakened patient.

As stated, the roentgen diagnosis of obstruction of small or large intestine without the aid of an opaque medium is dependent upon the finding of intraintestinal gas and fluid. Certain authors hold that gas found in the small intestine of patients beyond two years of age indicates obstruction; yet on numerous occasions during abdominal examinations for other than intestinal conditions, gas of varying amounts and fluid levels have been found in the small bowel. The writers are of the impression that fluid levels may be found more frequently in the nonobstructed case if the vertical position were utilized more commonly for other examinations.

Any active evacuant, especially the more irritating, may produce intestinal gas and fluid (Fig. 12). A series of examinations made after active catharsis by various means proved this contention; true enough, the amount in some instances was small, but in others sufficient to confuse one when the diagnosis of obstruction is under consideration. Since early purgation is usually practiced by patients suffering from abdominal symptoms, it becomes essential for the roentgenologist to be acquainted with the history before arriving at any conclusions. The postevacuant film with small intestinal gas and fluid usually can be differentiated from that of mechanical obstruction by the fact that large intestinal gas is rarely present in true obstruction of the small gut but is a common finding after catharsis.

Small intestinal gas is invariably found in the infant and in lesser amount in children up to ten years and older. In adults gaseous distention and occasionally fluid have been found with the following conditions: peritonitis, acute gallbladder and appendiceal pathology, ureteral calculus, allergy, severe abdominal trauma, fracture of lumbar vertebrae, acute pelvic conditions, *etc.* In these instances the intestinal stasis appears to result from a nonmechanical form of obstruction. In addition to the abnormalities mentioned, examina-

tions were made of debilitated patients suffering from nephritis, cardiac pathology, *etc.*, and frequently in these considerable gas collections were demonstrated in the small and large intestine (Fig. 10). Local areas of gaseous distention of small gut are very frequently associated with ureteral catheterization. The distention of the adynamic type of obstruction is usually much more generalized involving long continuous segments of the intestine, small and large; fluid levels may be present but more frequently are absent in this variety of stasis. Judging from the radiographic study of intestinal obstruction it appears that there frequently occurs an ileus of the adynamic type as a consequence to the underlying cause of a mechanical obstruction; this seems to be borne out by the fact that distention may be first found well above the point of mechanical obstruction, and secondly by the fact that the intestinal distention proximal to it is occasionally very extensive and uniform as noted with the adynamic variety.

Since intra-intestinal gas and fluid do not always indicate mechanical obstruction, it becomes important to decide if possible upon the criteria requisite for a roentgenologic differentiation as to the cause of distention. Experience proves the futility of dogmatic statements concerning this differentiation. The diagnosis of mechanical obstruction does not appear to be as dependent on the presence of gas and fluid within the intestine as upon the degree of distention. A small amount of intestinal gas is of little significance, while distention beyond the width of the normal lumen usually indicates obstruction and represents one of the most distinguishing diagnostic features of this condition; of greater importance is the persistence or increase of this distention after an interval. Frequently the original radiograph is not sufficiently characteristic to warrant a definite diagnosis of obstruction worthy of surgical interference. Consequently, reexaminations should be made at two-hour intervals while the findings are indefinite (Figs. 6 and 7).

While the gas collection usually increases with true obstruction, the amount may on occasions even be lessened after an interval. This has been noted in several cases of high jejunal distention; reverse peristalsis and regurgitation may account for its expulsion. Likewise, the intestinal pattern and fluid levels may be altered by a simple change of position of patient when the gas is free to pass from one to another loop above the site of obstruction. The important point appears to be that the distention just proximal to the point of obstruction, that is, the area of most distal distention, persists while the gas in the nonobstructive case usually passes on during the interim.

At times there appears a markedly distended loop of upper jejunum with a similar condition of the terminal ileum, while at operation but one point of obstruction may be noted and that in the most distal area. Apparently this results from a paresis of the gut proximal to the point of obstruction. Such possibility must be borne in mind when information is desired by the surgeon as to the site of obstruction.

TABLE I

Case No.	Age	Duration of Present Illness	Roentgenographic Findings			Location of Obstruction		Case No.	Age	Duration of Present Illness	Roentgenographic Findings			Surgery or Necropsy		Discharge Diagnosis	Remarks
			Intestinal Dilatation	Fluid Levels	Roentgen Ray	Surgery or Necropsy	Intestinal Dilatation				Fluid Levels	Ascribed to at Time of Roentgen Exam.	Surgery or Necropsy	Discharge Diagnosis			
1	20	22 hrs.	+	-	Distal ileum	Distal ileum	21	30	10 days	-	+	+	Enema?	Hemorrhoids		Hemorrhoids, rectocele	Had enema and mineral oil 12 hrs. before Enema
2	26	118 hrs.	+	+	Distal ileum	Distal ileum	22	65	4 days	+	+	+	Enema or obstruction?	Left ureteral calculus		Constipation	Enema 2 hrs. before Had castor oil and enemas Had enema 3 hrs. before
3	60	2 wks.	+	+	Distal ileum	Distal ileum	23	68	24 hrs.	-	+	+	Enema?	Left ureteral calculus		Left salpingo-oophoritis	
4	23	5 days	+	+	Proximal ileum	Proximal ileum	24	31	66 hrs.	+	+	+	Partial obstruction of descending colon			Acute cholecystitis	
5	67	5 days	+	+	Distal ileum	Distal ileum	25	35	64 hrs.	+	+	+	Enema or obstruction of ascending colon				
6	58	9 days	+	+	Descending colon	Descending colon	26	26	3½ days	+	+	+	Obstruction of ascending colon?			Ruptured peptic ulcer? Mesenteric thrombosis?	Had enemas and cathartics
7	64	10 days	+	-	Descending colon	Descending colon	27	52	2 mos.	+	-	-	Obstruction of transverse colon	Bilateral hydronephrosis		Bilateral hydronephrosis, cystitis, pyelitis	
8	56	3 days	+	-	Proximal ileum	Descending colon	28	18	12 days	+	-	-	No obstruction	Left ureteral calculus		Left ureteral calculus	Purgation and enema
9	50	6 hrs.	+	+	Descending colon	Descending colon	29	46	2 wks.	+	-	-	No obstruction	Right perinephritic abscess, ureteral calculus		Right perinephritic abscess, ureteral calculus	
10	28	10 days	+	-	Jejunum	Jejunum	30	35	6 days	+	+	+	No obstruction			Allergy	Had castor oil, enema 2 hrs. before No history of enema or cathartics
11	35	5 days	+	-	Descending colon	Descending colon	31	66	7 days	+	+	+	Obstruction of sigmoid colon	No obstruction		Hypertrophic colitis	
12	54	4 days	+	+	Midtransverse colon	Sigmoid	32	30	3 days	+	-	-	Obstruction of distal ileum?			Laceration of left kidney	
13	58	3 wks.	+	-	Descending colon	Descending colon	33	58	2 days	+	+	+	Enema or obstruction of ascending colon	Empyema of gall bladder		Empyema of gall bladder	Enema 7 hrs. before
14	47	96 hrs.	+	-	Lower jejunum	Jejunio-ileal	34	52	2 days	+	-	-	Stasis or obstruction of proximal ileum	Cholecystitis		Cholecystitis	No enema or cathartics
15	32	3 days	+	+	Distal ileum	Distal ileum and sigmoid	35	37	16 days	+	+	+	No obstruction	Retrocecal abscess		Retrocecal abscess.	No enema or cathartics
16	61	24 hrs.	+	+	Ileum and descending colon	Distal ileum and descending colon	36	63	5 days	+	-	-	Stasis in terminal and medial ileum	Metastatic epidermoid carcinoma of inguinal lymph nodes		Epidermoid carcinoma of vulva with metastasis	Effectual enema 1 hr. before
17	28	96 hrs.	+	+	Jejunum	Small intestine	37	67	52 hrs.	+	-	-	Obstruction of terminal ileum	Acute suppurative appendix		Acute suppurative appendix	No cathartics or enema
18	29	48 hrs.	+	-	Distal ileum	Distal ileum	38	49	6 days	+	-	-	Stasis or obstruction of distal ileum			Uremia, nephritis, syphilis	Bowel movements normal
19	14	3 days	+	+	Proximal ileum	Proximal ileum	39	40	4 days	+	-	-	Obstruction of distal ileum	Intestines markedly distended. Show no pathology. Lacerated liver		Intestines markedly distended. Show no pathology. Lacerated liver	Had enemas
20	41	2 wks.	+	+	Descending colon	Descending colon	40	48	3 days	+	+	+	Obstruction of proximal ileum			Compression fracture first lumbar vertebra	Enema 6 hrs. before

The problem involved in connection with this subject appears not to be in making the roentgen diagnosis of intestinal obstruction, but in excluding such a condition when it does not exist. Table I well demonstrates the difficulty; these cases represent 20 consecutive proven cases of intestinal obstruction and 20 of nonobstruction referred for abdominal study to confirm or exclude obstruction. In 12 cases, 60 per cent of mechanical obstruction cases, fluid levels were demonstrated; while in 11 cases representing 55 per cent of the nonobstructed group, this feature supposedly pathognomonic of dynamic obstruction was noted. In 100 per cent of the former and 90 per cent of the latter variety gaseous distention was noted. In many of the second group the possibility of obstruction could not be excluded on the initial examination. This form of investigation of the obstruction suspect becomes more dependable as a means of corroboration rather than exclusion of such a possibility. The roentgen diagnosis must be based on the degree of distention and the constancy of the findings.

CONCLUSIONS

Roentgen study of intestinal obstruction without the use of an opaque medium is very valuable but the diagnosis by this means is not always a simple matter.

Gas and fluid levels may be present in the intestine in the absence of obstruction.

Generalized distention, usually without intra-intestinal fluid, is noted in the paralytic form of obstruction.

While the important diagnostic features are the gaseous distention and fluid levels, interval examination to determine the persistence of these is often necessary for definite diagnosis.

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THE PROBLEM OF NON-CALCULOUS URETEROPELVIC OBSTRUCTION *

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THIS condition is not infrequently one of the most formidable problems with which the urologist has to deal. Inasmuch as the use of the ureteric catheter has failed to a considerable degree in overcoming and canalizing obstructions of the ureter at the level of the renal pelvis, we are forced to a consideration of some more adequate means of providing (renal) drainage. Moreover, it is to be noted that certain of these obstructions react unfavorably to instrumental ureteral manipulations. Given a case in a relatively young, vigorous person with an obstructive ureteropelvic lesion sufficient to produce rather severe symptoms with recurrences over a considerable period of time, in which the kidney is found to be functioning well, how is the operator to relieve this obstruction without sacrificing the kidney? We must face the challenge of providing adequate (reno-ureteral) drainage by conservative operation or remove the organ.

It is most unfortunate that the urologist sometimes finds it necessary to remove a kidney for a marked pyonephrosis as the end result of severe obstruction from stenosis, stricture or aberrant vessel at the pelvic outlet. We recently removed a kidney in an advanced state of disease in a boy of eight years. It is worthy of note that the history of pain was only of three weeks' duration with no previous attacks. He had urographic evidence of slight obstruction to the pelvis of the remaining kidney without pain. I believe there is an aberrant vessel on this side and have determined to operate at the first sign of definite renal pain, should it occur. Four months ago a pyonephrotic kidney was removed in a woman 36 years of age who gave a history of intermittent pain for twenty years. She had never been cystoscoped. The pelvis was of the intrarenal type, with the outlet almost effaced by a very dense, thick stricture.

It is worthy of note that the larger percentage of these lesions occur in minors and relatively young adults. Obviously in the poorer-risk patient and the one more advanced in years, plastic operations may be very unwise. On the other hand, where the opposite kidney has been removed or where its function is markedly impaired, one is forced to undertake a conservative plastic procedure.

To recapitulate, the following are the chief causes of high obstruction: (1) Stenosis or stricture at the ureteropelvic junction; (2) congenital muscular hypertrophic stenosis caused by hypertrophy of the middle circular layer

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of smooth muscle:—this might be considered an analogue of congenital pyloric stenosis; (3) aberrant renal vessels; (4) ptosis of kidney with redundancy and kinking of the ureter; (5) periureteral bands or adhesions; (6) stricture after injuries or operative procedures; (7) pressure of new growth from without; (8) valve-like projections of ureter into pelvis or pelvis into ureter; (9) abnormally high and oblique insertion of the ureter; (10) renal sympatheticotonia; so-called by Harris and Harris.¹³ This is presumably a condition of spasm of the smooth musculature due to overstimulation of the vasoconstrictor fibers of the sympathetic nerves often associated with mild hydronephrosis and with no other mechanical obstruction. This last condition may not be generally accepted. A. von Lichtenberg¹¹ has encountered dynamic or functional spasm of the circular muscle (as in pylorospasm) not infrequently and has observed marked spasm at the ureteral outlet during operation. He usually dilates the orifice through a small pyelotomy incision and cuts the circular muscle at the junction, closing the incision in the opposite direction. It must be stated that in about one-half of his plastic cases he was unable to demonstrate a true mechanical obstruction, a fact that would indicate that the spasm from disturbed neuromuscular function may have been, in reality, the functional syndrome of Harris and Harris¹³ and of Papin. Perhaps renal sympathectomy would be the logical procedure for cure of this dynamic spasm. It is quite dramatic to see the relief of severe spasmodic recurrent renal colic afforded by means of renal sympathectomy. This syndrome helps to explain the existence of hydronephrosis in the absence of any demonstrable obstruction.

It will be noted that we have not mentioned the most common of all obstructions at this level, namely, calculus. In the absence of any of the previously mentioned conditions, simple pyelotomy and stone removal afford relief unless the resultant renal damage requires nephrectomy. In calculus associated with extrarenal hydronephrosis, it would seem wise to resect a fairly sizable portion of the renal pelvis, in the hope of minimizing the factor of urinary stasis. We have done this a number of times with gratifying results. In resecting tissue of the pelvis it appears logical to remove it from either the superior or the inferior border according to the circumstances, taking away an approximately equal amount of tissue from both the anterior and posterior surfaces. In so doing, there is no distortion of tissue following closure of the incision and the ureteropelvic relationship is not altered.

Ptosis with kinking of the ureter has not been discussed, as the diagnosis and operative procedure are usually simple and the results excellent.

In the case of removing periureteral bands near the pelvis, resulting from old inflammation or following former injuries, we believe the use of the No. 8 F. ureteral catheter to splint the ureter during the period of healing to be very advisable. This will maintain its proper direction and reduce materially the tendency to distortion. This procedure was applied in a young woman who had two dense linear strictures in the wall of the ureter 2 cm. apart and 3 cm. below the pelvis, after repeated attempts to pass any instruments

through the obstruction from below had failed. At operation, through the pyelotomy opening the ureter could be gradually dilated from above downward, using small sizes at first. The catheter was left *in situ* for one week bringing it out transrenally through the opening made by a trocar. I have never encountered such strictures in the walls of the upper ureter at any distance from the pelvis.

When an aberrant vessel of moderate size is encountered, (with or without an associated interstitial band, and with or without ptosis), section of the vessel, removal of the interstitial band, if present, and anchoring the kidney in high position, if necessary, is usually all that is required. Partial resection of a large redundant pelvis resulting from this condition may also seem advisable.

Plastic procedures for the relief of other forms of obstruction have seemingly been largely abandoned by many competent urologists because of the rather large percentage of bad end-results requiring secondary nephrectomy. A. J. Scholl and E. S. Judd³ have reported a series of 39 plastic operations on the pelvis in 11 of which secondary nephrectomy was required; a percentage of failure of about 28 per cent. Eisendrath states that, "of all the types of pyeloplasty, reimplantation of the ureter offers the best outlook." Because of two unfortunate experiences of the past, in severing the ureter completely, and failure after suture, requiring nephrectomy, we are fearful regarding complete division of the ureter at or near the pelvis. There is a rather general opinion to the effect that once the ureter is severed, the kidney to all practical purposes cannot be saved. Wildbolz appears to have been very successful with reimplantation of the ureter for aberrant renal vessel where he prefers this procedure to sacrificing the vessel. He objects to the resultant necrosis, scarring and diminished renal function resulting from section of the vessel and reports a considerable degree of success in maintaining good renal function, even several years following replacement of the ureter to a correct position and suture to the pelvis.

A. von Lichtenberg¹¹ has reported 47 conservative operations, in only three of which secondary nephrectomy was required. However, instead of transplanting the ureter in conditions of aberrant vessel, he sections the accessory vessels, to avoid disturbance of function which he believes is the result of dividing the nerves. In this connection, one must be mindful of the fact that accessory vessel obstruction is very frequently bilateral and one may hesitate to cut sizable arteries on both sides where a considerable degree of bilateral obstruction results from them. This amounts to bilateral partial nephrectomy.

Marion and Legueu go so far as to state that suture of the ureter is useless. This statement does not seem well founded, in view of the brilliant, though limited, success obtained by certain operators over periods of 10 to 20 years.

Quinby⁷ has reported uniform success in seven cases with transplantation of the ureter into the dependent portion of the pelvis. In some of these,

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many years had elapsed before reporting end-results. In each of this series an aberrant vessel was the cause of obstruction. While symptomatic relief and maintenance of good renal function was obtained, subsequent pyelographic study has been recorded in only two or three of the entire series. He has been much more successful with ureteropelvic anastomosis than with longitudinal incision and transverse closure of the outlet. He never employs an indwelling ureteral catheter and rarely performs nephrostomy. In a recent personal communication he reports that his end-results continue to be entirely satisfactory.

A. von Lichtenberg's unusual success in plastic procedures may be largely due to his routine nephrostomy drainage, which he considers indispensable. He rarely performs partial resection or plication of a redundant pelvis and usually reimplants the ureter for conditions of abnormal insertion. Waltman Walters¹² has reported success after pelvic resections in a number of cases. One of these included a repair procedure on both pelves. What is more significant than this, is the fact that ureteropyeloneostomy performed by him for the relief of a completely obstructed (acquired) solitary kidney, showed a successful result four years afterward. He recommends transplantation of the ureter in preference to ligation of large accessory vessels. He reminds us that the vessels should first be temporarily compressed with a rubber covered hemostat to determine the amount of interference with renal circulation. This should be the deciding factor as to whether the vessel should be sacrificed. This technical procedure was well demonstrated in one of my own patients, a child of twelve years, in whom clamp compression of a fair-sized aberrant vein affected the circulation in the lower one-third of the kidney only temporarily. The application of hot compresses to the kidney brought back the natural color after a few minutes. There was no aberrant artery.

The scope of this report does not permit of a consideration of all the types of plastic procedures devised. The Heineke-Mikulicz principle of pyeloplasty is still used to some extent—to widen the ureteropelvic orifice, making a longitudinal incision and closing it transversely in the opposite direction, so that the extremities of the original incision become the central point in the suture line. This method was applied in two of our cases. It is important to remember that too long an incision puts too great tension on the sutures, whereas too short an incision leaves the aperture too small, with stenosis likely to recur. Some have successfully employed a Y-shaped incision for widening the aperture for a strictural condition. It is to be noted in all plastic work that stenosis may progress after operation very gradually so that the immediate functional capacity may be normal, whereas, after a term of years, it may be one-half or one-third normal, until ultimately the obstruction effects complete atrophy. On the other hand, there are records to show ureters remaining patent for as long as 20 years, where the kidney had gradually lost its function completely. It is

obvious that one cannot consider end-results without a prolonged period of observation.

Dr. Charles H. Peck⁶ has contributed a very useful principle of splinting the ureter by the passage of a catheter well down to the bladder and bringing it out through the kidney cortex after making a small stab wound through the kidney. The proximal end is brought out through the upper angle of the incision and is left in position for four to six days to canalize the lumen of the ureteral opening and to prevent distortion and kinking during the earlier stages of healing. We have used this method a number of times and believe it is a valuable aid in minimizing and preventing post-operative stenosis. To reduce the amount of trauma to the kidney substance in passing a clamp or other instrument through the kidney, we have devised two small six-inch trocars (with round points), the lumina of which accommodate a No. 6 F. and No. 8 F. ureteral catheter or bougie respectively. A long (urethral) alligator forcep is very useful in making the nephrostomy wound for placing the nephrostomy tube and minimizes the parenchymal damage.

Küster was among the first to implant the ureter into the pelvis successfully in 1891 and Fenger performed a similar operation shortly afterward. He speaks of probing the ureter with a No. 9 F. to No. 12 F. metal bougie through the kidney wound; apparently he employed nephrostomy drainage, a factor which may have contributed largely to the satisfactory result.

The results of the animal experimental work of Iselin¹⁰ afford a more hopeful outlook in ureteropyeloplasty. He concludes that ureteral section does not ultimately necessitate nephrectomy for a resultant degenerated and atrophied kidney as formally claimed, but that the stenosis from healing is the serious complication and the cause of the bad results. He argues and has shown, to some extent, at least, that by "side-tracking" the urine flow by pyelostomy above the point of suture and by placing a No. 8 F. to No. 10 F. ureteral bougie down the ureter, favorable results will follow ureteropelvic anastomosis. He warns that eversion is to be avoided by removal of any redundant portion of the mucous membrane of the ureter. In a limited number of dogs he found that loss of peristalsis occurred temporarily in the proximal portion of the severed end. The regular motility, however, returned normally within a few weeks and kymographic tracings recorded this activity as long as 102 days after ureteral section. The persistence of inertia was only seen in the presence of cicatricial stenosis.

A study of the literature reveals numerous failures where the ureter was inserted with projection into the pelvis, and valve-like elevations resulted. Certainly, end-to-end closure appears to be the better method.

CONCLUSIONS

It seems reasonable to conclude, therefore, that the following fundamental principles of technic in all plastic operations on the pelvis assure greater safety and hope of success. (1) Following operation, a No. 6 F. to No. 8 F.

ureteric catheter or bougie should be passed down the ureter and brought out through the kidney and upper angle of the wound (Peck method) and left in position for five to seven days. (2) In anastomotic procedures the pelvis should be drained through a nephrotomy wound by a catheter of size 14 F. to 16 F. for a period of five or more days. Nephrostomy is as logical in this instance as cystotomy for plastic operations on the urethra. This eliminates the effect of increased intrarenal pressure and stasis, upon the kidney and the suture line, and meets the factor of associated infection. (3) End-to-end ureteropelvic anastomosis offers a better outlook than other methods of partial plastic repair of the outlet and is preferable to insertion of the severed ureter stump into the cavity of the pelvis. (4) The perirenal space should also be adequately drained for, at least, a week after operation.

It is to be hoped that plastic surgery of the pelvis will, in the not distant future, prove to be more practical and useful, and that errors and pitfalls may be overcome, to the end that many kidneys may be saved. It would seem advantageous to have some clearing house or reference bureau to record data of all plastic work done by various operators, in America; this to include continued follow up information.

Further experimental work along the line of that of Iselin appears necessary.

Appended are four histories of recent cases, illustrative of conservative operative procedures which have resulted in complete relief of symptoms and conservation of a normally functioning kidney.

CASE REPORTS

CASE I.—Hydronephrosis—Linear Stricture of the Ureter at the Junction of the Pelvis—Incision and Plastic Repair.—J. M., a vigorous male of 43 years, hospital orderly, was admitted September 11, 1934, with severe attack of left renal colic of two days' duration requiring morphine for temporary relief. This was accompanied by fever and typical tenderness over the affected kidney. There was a rather long history of backache and fatigue on exertion; the last severe attack of colic occurred about two months before admission. History and physical examination and laboratory data were essentially negative, excepting the urinary tract.

Cystoscopy revealed an apparent obstruction to the catheter in the region of the pelvis on the left side with moderate pyuria and normal differential P. S. P. test. The right renal urine was clear with normal elimination of the dye. There was a small faint shadow in the region of the pelvis which was interpreted as a possible calculus. Ureteropyelogram revealed an hydronephrosis with obstruction at the pelvic outlet either from aberrant vessel or stricture. Operation, a few days later, revealed a slightly enlarged kidney which appeared well preserved. A very short vascular pedicle, even after rib resection, did not permit of delivery of the kidney. A dense linear stricture was encountered at the junction of the pelvis and ureter about one-half inch long. Pyelotomy together with careful search of the pelvis, and calices, including needling of the kidney, failed to disclose a stone. The wall of the pelvis was considerably thickened. An incision was made through the dense strictured ureter, and a modified Heineke-Mikulicz repair procedure was done with a catheter in the ureter, making an ample aperture at this site. The operation was quite difficult owing to the short vascular pedicle and required two hours for completion. There was a moderate febrile course for six to seven days with rather free urinary drainage from

the loin. Twelve days after operation an indwelling ureteric catheter was passed into the pelvis from below and left in position for 48 hours. Again, four weeks after operation, a No. 9 F. Garceau catheter was passed and left in position and the patient was discharged from the hospital five weeks after operation with flank wound almost completely dry. About one week later there was a return of moderate urinary drainage for a few days, after which the wound closed permanently. A catheter was subsequently passed easily on two occasions at intervals of four to six weeks. On February 12, a No. 9 F. Garceau catheter was easily passed and urine found to contain small amounts of pus. The P. S. P. test was normal. On the preceding cystoscopy the urine from the left kidney was clear. Patient is continuing his usual occupation and enjoying excellent health. He has gained considerable weight and appears robust.

CASE II.—*Hydronephrosis—Stenosis of Ureteropelvic Outlet and Hypertrophy of Ring Muscle—Incisions and Plastic Repair.*—Mrs. A. C., housewife, 30 years of age, was admitted September 13, 1934, with complaint of persistent pain of varying severity in the right lumbar region and flank of eight months' duration. The pain was often aggravated by physical exertion. There was moderate tenderness and jar tenderness over the right kidney, the kidney was not palpable. The catheter passed readily to both pelves with return of moderately cloudy urine from right and clear urine from left. The P. S. P. test was normal on both sides. Ureteropyelogram revealed a mild hydronephrosis on the right side and suggested a kinking and angulation of a redundant ureter. There was also a greater amount of hydronephrosis on the left or symptomless side. At operation the right ureteropelvic junction was found to be definitely stenotic, with hypertrophy of the ring muscle at this point. There was no ptosis or unusual mobility of kidney. Pyelotomy incision was made, exposing the orifice from within. Two small incisions were made through the mucosa and musculature on the interior and a third incision was carried completely through the area of obstruction. With a catheter in the ureter, a closure in the opposite direction was made providing an ample opening. The appearance after closure seemed so satisfactory that no indwelling catheter was used. I believe this was a mistake and that the subsequent pyelogram proved that temporary stenosis, at least, occurred with increased intrarenal pressure and dilatation of calices. Moderate urinary leakage occurred from the wound for eight days. An indwelling catheter below for 48 hours kept the flank dry. Two weeks after operation a second indwelling catheter was placed because of slight urinary drainage from the wound, and, three days subsequently (17 days after operation), patient was discharged from the hospital with the wound completely healed. Since that time the ureter has been catheterized on two occasions, the last time on February 18, 1935, when the urine was perfectly clear and the P. S. P. test normal. The pyelogram, however, showed greater dilatation than before operation and we were surprised, inasmuch as there has been no pain or renal tenderness since.

In cases of this type we believe the catheter splint is of definite value and should be used as a routine. When infection is associated, nephrostomy with 14 F. to 16 F. tube is advisable.

Since this report was made a similar plastic procedure was done on the opposite kidney pelvis with drainage with complete success. This was required for relief of severe obstruction and persistent colic.

CASE III.—*Hydronephrosis—Aberrant Renal Vein—Resection of Aberrant Vessel and Redundant Pelvis.*—Mrs. M. F., housewife, 36 years of age, was admitted September 12, 1934, with pain in the left lumbar region radiating downward and forward from which she had suffered during the preceding four months. Several severe attacks during this time were not relieved by medication. There was moderate tenderness in the left flank with kidney not palpable. The physical examination and laboratory work were essentially negative, excepting ventricular myocardial disease as proven by the cardiogram.

Cystoscopic and pyelographic study showed bilateral hydronephrosis with the film appearing typical of bilateral aberrant vessels. Both kidneys showed normal function and

were free of infection. It is interesting to note that greater dilatation occurred on the symptomless side. At operation a moderate sized vein was found to cross the junction anteriorly in such a manner as to definitely obstruct, and the vessel entered the lower pole of the kidney. The hydronephrosis was greater than indicated on the pyelogram. There was no interstitial band or demonstrable ptosis. The vessel was clamped in two places and resected. Following this an elliptical portion of the redundant pelvis was resected from the lower border, removing an equal amount of tissue, half from the anterior and half from the posterior surfaces. An inlying No. 8 F. splint catheter was brought out through the kidney and left in for seven days. There was some febrile reaction for about eight days. Moderate urinary drainage from the flank continued for 10 or 11 days. Patient was discharged in excellent condition, 18 days after operation, with wound healed.

Symptoms have been completely relieved. Pyelography on January 29 showed some hydronephrosis remaining on left side, despite pelvic resection. The first pyelogram had evidently not filled the left pelvis completely. Hydronephrotic drip was found only on the right side (non-operated) at the last examination.

CASE IV.—*Renal Sympatheticotonia or Sympathetic Nerve—Muscle Spasm—Renal Sympathectomy.*—Miss H. W., a nurse in training, aged 21, was admitted to the hospital August 15, 1934, with severe and persistent left renal colic. She had been admitted to the hospital on three previous occasions for relief of pain which at times appeared to be typical of stone in the kidney or ureter. She was of a distinctly emotional type and had suffered from some ovarian dysfunction with endometrial hyperplasia for which she had been treated by a gynecologist. Two years before I had thoroughly studied this patient by cystoscope and by intravenous urography and retrograde pyelography. She remained in the hospital for one month. A diagnosis of sympatheticotonia was made. She was advised to live out of doors for six months and eserine was given intermittently by mouth. Persistent colic recurring, she was again thoroughly studied and no other lesion of the ureter or pelvis could be demonstrated. Repeated narcotics and sedatives in large doses had failed to give relief and sympathectomy was decided upon. Operation performed August 21, 1934. The sympathetic nerve structures were removed from the renal pedicle and upper third of the ureter. She has obtained complete relief from the renal pain. This is the fifth successful case of sympathectomy in our series where all conservative treatment and in whom the use of eserine and other antispasmodics were of no avail.

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THE TREATMENT OF COMPOUND FRACTURES WITH SPECIAL REFERENCE TO THE ORR METHOD*

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COMPOUND fractures have always constituted an important group of civil and industrial injuries. With the ever increasing number of automobile accidents, all surgeons are being called upon to treat more of these cases each year. The results at the present time vary all the way from brilliant to horrible, and any method recommended to the surgical profession at large should be one which the surgeon of average skill and experience will be able to carry out in the hospital of average equipment and personnel.

The methods of treating this group of injuries have varied from time to time with changing concepts of the treatment of infected wounds. In the early days of surgery compound fractures frequently resulted in death or amputation and whether this was done early or late depended on such factors as location, severity, hemorrhage or infection. From the adoption of antiseptic surgery the attention of surgeons has been primarily concentrated on the problem of handling infection in these cases. This undoubtedly worthy objective has, however, not always worked to the ultimate benefit of the patient, for, in concentrating upon the problem of infection, the fracture has been neglected. Too often one hears the statement that "we must forget the fracture and treat the patient." This is, of course, a most comfortable attitude for the surgeon to assume because it immediately relieves him of all responsibility for a bad result and places the burden on the Almighty. Of compound fractures Orr has said that the principles of orthopedic treatment have been sacrificed to the supposedly necessary but actually dangerous combatting of infection within the wound. With the introduction of the Carrel-Dakin treatment of wounds the ultimate in this point of view was achieved. No one can dispute the brilliant results that were obtained by the correct application of this method if our estimate is limited to a consideration of the infected wound alone, but neither can it be denied that it often disregarded the fracture. The infected wounds cleaned up and healed, but the records of the surgeon general's office show a disheartening number of patients still disabled on account of this disregard. Another objection to the Carrel-Dakin technic is its complexity and the demands that it makes for a highly trained organization. One gets the distinct impression that this form of treatment is losing favor and it is not at all uncommon to find interns, recently graduated from our best medical schools, who have never heard of it, or, if so, have never seen it used. Diametrically opposed to the Carrel-Dakin treatment, we have the advo-

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cates of immediate closure, with or without internal fixation. To Sherman, of Pittsburgh, must be given the credit for the advancement of this practice and in his hands the results seem to have justified his enthusiasm. The disastrous results in the hands of others not so preeminently qualified, however, would lead us to question the safety of recommending it freely and for situations different from those in which his successful results have been achieved.

Between these two extremes we find a great variety of practice. Cotton, writing in Lewis' Surgery, states that débridement, half closure, with drainage by leakage and delay of corrective surgery until later offer the best solution of the problem.

It would appear from this that there is little uniformity of opinion regarding the management of compound fractures. However, surgeons experienced in this type of work agree that all compound fractures are grave surgical emergencies requiring immediate operation. The nature of the surgery required is worthy of the best efforts of the mature surgeon and should not be delegated to inexperienced assistants. There are some who still attempt to differentiate between the fracture that is compounded from within and from without, claiming that the former is a wound made by a sterile instrument not requiring the same extensive exposure and débridement as the latter. We are in absolute disagreement with this point of view and regard it as a matter of academic interest only. It should also be emphasized that the external appearance of a wound is not a reliable criterion by which to judge of its internal extent. In one case, that of a fracture involving the ankle joint, the external wound was not more than an inch in diameter and yet after wide exposure a piece of stocking about three inches square was removed from the interior of the joint. In another case of fracture of the tibia, the external wound was apparently insignificant. A junior member of the department who saw the case reported by telephone that the wound was so slight that he did not feel justified in making a wide exposure, particularly since the fracture was in good position. The wound was disinfected superficially and plaster applied. The result was a virulent infection which nearly cost the patient his leg and his life. The extent of the internal damage disclosed at the second operation was most instructive. The patient fortunately made a good recovery eventually but only after prolonged hospitalization punctuated by repeated operations for the evacuation of pus.

In attempting to rationalize the treatment of compound fractures, Orr has stated four hypotheses upon which he bases his method. These are: (1) The use of antiseptics in the treatment of infected wounds has developed to the point of abuse. (2) It seems that it is not generally known that infected wounds do heal without the application of antiseptics of any kind. (3) Wounds if properly protected will heal consistently without daily dressings or irrigation with antiseptics in a way that is at once easier and better. (4) The important factors in securing these better results are: (a) Primary asepsis or antisepsis when required. (b) Adequate drainage. (c) Immobili-

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zation of injured parts. (d) Protection of wounds against disturbance and reinfection. It should be understood that the Orr method introduces no new principle in the treatment of compound fractures, but merely applies the well established principles of asepsis and immobilization in a somewhat different manner from that formerly recommended.

In the five years that we have been employing this method of treatment we have found it advisable to modify our original technic in some respects. Our present plan is as follows:

After the patient has been anesthetized, and not until then, the temporary splints and dressings are removed. A pad saturated with alcohol is laid over the wound and the entire extremity is shaved and then cleaned with ether and alcohol and painted with tincture of metaphen or iodine. The external wound is then accorded the same preparation.

A careful and systematic disinfection is then carried out, including excision of the wound margins, removal of all devitalized muscle and completely detached bone. Length and contour are then restored by traction and manipulation. The entire wound is then flooded with ether which often discloses bleeding points otherwise overlooked. The wound is next packed with sterile vaseline gauze, an important part of the operation. The packing should fill the entire wound. It should be placed in contact with the bone; the wound edges should be lifted up and the gauze placed beneath them. The gauze must be thoroughly impregnated with the vaseline and should be reasonably fresh. Gauze which has been repeatedly sterilized tends to become weak and upon removal individual cotton strands may be lost in the granulations and give rise to annoying residual infection of a low grade. Over the pack, vaselined strips of gauze and cotton is applied. A smooth, snug bandage covers the whole area. The limb is then immobilized by complete circular encasement in plaster of paris. No splitting or fenestration is permissible.

In fractures involving joints, this technic is modified in that the joint cavity, after thorough lavage with ether and particular attention to hemostasis, is closed with interrupted sutures of plain catgut. This plan was adopted in view of the impossibility of maintaining sterility of an open joint after dressings are finally begun. In cases where the joint has been closed we have had no trouble. The rest of the wound is packed as in the ordinary case.

The management from this point on is that of a closed fracture, no dressing being made for at least four weeks. In our earlier cases we kept our patients in the hospital until the first dressing was made. We now keep them in for one week. During the first few days there may be a slight elevation of the temperature (100° – 102°) but this need cause no anxiety. It must be remembered that there is usually some temperature reaction following a simple fracture. If at the end of one week the temperature is normal, the patient is allowed to go home, returning in four to six weeks when the plaster case is removed.

In most instances the granulations will have pushed the packing up from the depths of the wound and one finds a clean, red, granulating surface with the bone completely covered. If there is a good firm base of granulation tissue, it is covered at once with pinch grafts. The grafts are covered with paraffin mesh and over this a pressure dressing of either rubber sponge or cotton is placed and held by adhesive strapping. Another plaster case is applied and no further dressing is made until union is complete. If skin grafting is not done at this time, the wound is simply cleansed with ether and covered with vaselinized strips of gauze and another case applied. This is the only dressing that is made until complete union has occurred. Occasionally one encounters difficulty with adult patients who become convinced that they are being neglected because they are not dressed. This dissatisfaction is augmented by visitors, who, unhampered by facts or information, regale the patients with gruesome tales of legs lost and so on. A little time spent in explaining the situation often prevents this sort of criticism. To overcome the odor, which is objectionable, various modifications have been suggested regarding the material used to impregnate the gauze pack. It can be helped but not prevented by using a gauze impregnated with both iodoform and vaselin, or by employing bismuth iodoform paste (BIPP). Thymol has also been suggested as a deodorant. The odor, of course, comes not from the wound but from the decomposing secretions in the unchanged dressings. It is a peculiar, highly characteristic smell, alike in all cases, and seems to indicate that the process is due to some specific factor or factors, as in the ripening of the various odoriferous cheeses. The liquefied secretion about the wound is dark, mucilaginous, and non-irritating to the tissues. We have not been able to attribute any of the effects of the treatment to the development of bacteriophage, though this has been suggested. It probably is not a matter of great importance what substance is used as far as the ultimate result is concerned and in the various published reports on this method probably a little too much emphasis has been placed on the vaselinized gauze. The important feature is that the mechanically disinfected wound is filled with a bland substance which will allow granulation to proceed and which prevents puddling in a wound covered with an occlusive dressing. We have adhered to the simple yellow vaseline gauze and encouraged the patients to endure the odor.

The convalescence of these patients is in marked contrast to those treated by the more familiar methods that required frequent dressings which not only were a source of dread to the patient, but which of necessity militated against adequate retention of the fracture and imposed the risk of superinfection. Our observations of compound fractures have led to the strong conviction that the suppuration which is so frequently seen is the result of infection introduced at these dressings. The following case is cited to illustrate this point:

CASE REPORT.—S. B., aged 50, a colored man, employed as a stevedore, sustained a compound comminuted fracture of the femur just above the knee joint, when a heavy packing case fell on him. In addition to the fracture of the femur he sustained a fracture

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of the nose and maxilla and multiple lacerations of the face. He was in profound shock upon admission. The upper fragment of the femur was protruding through his overalls. After instituting measures for the relief of shock, the wound on the outer aspect of the thigh was flooded with iodine and covered with a sterile dressing. During the first 24 hours his condition was such as to warrant nothing beyond temporary extension in a Thomas splint. At the end of this time, under local anesthesia the wound was systematically cleaned out, the protruding bone replaced and the limb suspended in a Thomas splint from a Balkan frame in the usual manner. Plaster was not applied. The wound was not dressed and bedside roentgenograms at the end of the fourth day showed that the displacement of the upper fragment had been overcome and although there were 14 fragments present, the alignment was excellent. During the following three weeks the wound was not disturbed by any sort of dressing and the patient had no elevation of temperature. During the fourth week, a new house officer, becoming alarmed by the odor of the dressing, removed the packing, swabbed the wound with mercurochrome and repacked with plain gauze. On the following day the temperature rose sharply to 103° F. and from that point the patient was septic and developed an extensive cellulitis of the thigh which required multiple operations for relief. Union of the fracture, however, occurred but the infection in the depths of the wound prolonged hospitalization for many months.

The objections to the Orr treatment are based largely upon the hesitation almost instinctively aroused in any surgeon's mind as to the danger of encasing a presumably infected wound in plaster, and particularly the danger of anaerobic infection. Experience has demonstrated, however, that this fear is not warranted by the results and *a priori* objections must give way in the presence of facts. In our own case we were led rather easily to give the plan a trial because we had become convinced that prevailing methods, especially that of immediate suture, were dangerous or inadequate especially in wounds potentially contaminated with anaerobic organisms. We had been using with satisfaction open treatment with immobilization and it was not a violent break to employ vaselinized gauze as a pack and cover the wound for a longer period.

Anaerobic infection is certainly to be considered in any injury the result of a street or a farm accident and due precautions must be taken against it. While the incidence of tetanus appears to be on the decrease, in the Philadelphia area at least, we are seeing more cases of gas gangrene than formerly. A number of writers have drawn attention to this in the recent literature of gas gangrene in civil practice. Recognizing this danger in all compound fracture cases, whether treated by the Orr method or not, a prophylactic dose of the combined tetanus and gas serum should be given. Before the introduction of the combined serum we employed the two separately, first using the perfringens and later the polyvalent serum. The justification for giving gas or combined serum to these cases has been questioned by some surgeons on the ground that it was unnecessary, although those who question it do not hesitate to give antitetanic serum in all street injuries. It is admitted that in many instances this is an unnecessary precaution but it would seem quite as logical to give the combined serum as antitetanic serum alone. Others advance the argument that wounds such as commonly accompany compound fractures should be dressed in a manner permitting frequent in-

spection and dressing, in order that proper measures may be applied to the infection which so frequently appears. The answer to this objection is that cases treated by the Orr method do not become infected and that wound infection and osteomyelitis are more often the result of meddlesome dressings than of original contamination.

It must be clearly understood that this method of dressing is not advocated in every case of compound fracture. In our experience it is not satisfactory in femur fractures. The femur lies in the center of a large muscle mass and it is not possible to place the packing in such a way as to prevent puddling in the tissues below and internal to the fracture. In these cases better results are obtained by dakinization combined with some method of suspension and traction. In "stripping" injuries it should not be used unless the wound is very widely opened. In the case seen late and presumably already infected it is usually contra-indicated. On the other hand in old compound fractures with non-union and low grade infection it may be employed with confidence as an adjunct to whatever method of fixation is elected. The following case is illustrative of this point.

CASE REPORT.—E. W., a man, aged 32, was admitted to Abington Hospital in September, 1934, giving a history of having sustained a compound fracture of the tibia seven months before. He had been treated in a fracture box and antiseptic dressings applied to the wound for a week. At the end of that time the fracture was plated and put up in a fenestrated case. Daily dressings were made. Infection, of course, set in, the plate loosened and came off. The attending surgeon then applied a larger plate and repeated the same after treatment with the same result. He then wired the fragments together. During all this time, daily or every other day, the wound was dressed. Finally, the patient was informed that nothing could be done for him and that his leg would probably have to be amputated. As he was a long way from home he elected to sign a release and enter a hospital in his own neighborhood for the operation. On admission he was wearing a fenestrated case. A wound eight inches long and two inches wide, sloughing, dirty and discharging pus was disclosed. In the wound the bone could be seen plainly, about four inches being exposed. The bone looked like a piece of coal, was denuded of periosteum and the fracture, a slightly oblique one, was held in place by a silver wire. There was no evidence of any attempt at callus formation.

Under general anesthesia the wound was excised widely, the wire removed, the ends of the bone freshed and the wound allowed to bleed itself full. When clotting had occurred it was covered with vaseline strips and a plaster case without fenestrations applied from the toes to the mid thigh. No dressing was made for four weeks when the case was removed. The wound was clean and granulations were partially filling it. The bone, however, was not covered at all at the site of the fracture, but was of a better color. A second case was applied and the patient was allowed to go home the next day. Four weeks later, the wound was still clean but the bone was still widely exposed and no union had taken place. Full thickness graft six inches long taken from the opposite tibia was laid in after the Albee technic, the wound packed with vaseline gauze and the limb encased in plaster. In spite of the open and presumably infected field, the graft took and firm union was secured. The patient was dressed only twice during this period following the operation and is now walking with a brace without the aid of crutches. The wound healed nicely by granulation.

The conclusions reached regarding the management of compound fractures are based upon the following experience.

COMPOUND FRACTURES

In a period of slightly more than five years we treated 203 compound fractures. We exclude those dying of associated injuries. Of these, 106 were treated by the Orr method. Of the 97 treated by other methods, three were partially closed and drained, two were immediately closed, and the remaining 92 were treated by wide open drainage and dakinization or simply by packing and immobilization. In the entire group there were five amputations. Two of these were in cases treated by the Orr method, one of these required amputation because of extensive damage to the blood supply and not on account of infection (amputation should have been performed at the time of the original operation); the other Orr case requiring operation developed generalized gas infection within 24 hours. This was a man with extensive crushing injuries to both the leg and thigh inflicted by a farm tractor. Owing to his condition no débridement could be done and several of the principles of the Orr method were violated. It was realized at the time that the treatment was unsatisfactory but it seemed that nothing else was immediately possible. The three remaining amputations were due to hemorrhage and shock. With the time of the first operation. In the entire group there were three deaths. One death was in the case just referred to; the other two occurred 24 and 48 hours after the injury and were due to hemorrhage and shock. With the exception of the two cases of amputation, we have not found it necessary to remove or open a single plaster case for infection. One case was recently removed at the end of a week in order to secure better position of the fracture but the packing was not removed and another encasement applied at once, the patient progressing to an uneventful recovery.

CONCLUSIONS

In the great majority of compound fractures, the Orr procedure is the method of choice.
The procedure is relatively simple and can be carried out under ordinary hospital conditions.

It is emphasized, however, that the essential conditions must be rigorously fulfilled and inability to meet them *in toto* may call for a complete change of plan.

The chief contraindication to the method, in our opinion, is the existence of extensive devitalizing injuries involving large muscle masses when adequate débridement is impracticable and complete immobilization difficult or impossible.

DISCUSSION.—DR. FREDERIC W. BANCROFT (New York).—Doctor Pfeiffer has brought up a very controversial subject in his paper on the Treatment of Compound Fractures. He has said there are three main methods of treating compound fractures:

- (1) Leaving of the wound wide open, after careful débridement and treatment with Carrel-Dakin solution.
- (2) Thorough débridement and closure, the closure being either primary or delayed, with the use of some intermediary treatment like Carrel-Dakin until the wound is bacteriologically clear.

(3) The Orr treatment.

Each one of these methods has its own advocates and each method has shown satisfactory results where good surgery is first performed and the postoperative care has been meticulously carried out. There is no doubt that the individual fitness and inclination of the surgeon, and the equipment and the personnel available for the after care, influence these results.

Doctor Pfeiffer in his summary states that in five years he and Doctor Smyth, Jr., have treated 203 cases of compound fracture: Of these 106 were treated by the Orr method and 97 were treated by other means. Of these 97, 92 cases were treated by wide open drainage and dakinization. I should like to ask Doctor Pfeiffer if the 106 cases treated by the Orr method have been consecutive and the latest cases treated or whether he uses selection in the type of cases. (I assume by his statement that compound fractures of the femur are not treated by the Orr method.) I feel this question is pertinent because it seems to me that there is sufficient good in each method of treatment so that one should not be an advocate of one sole procedure. The type of fracture, the location of the fracture and the amount of contamination that a compound fracture receives must be considered before deciding on the therapy. I do not believe that any one method is applicable to all types of fracture. The initial principles as set down by Orr should be the initial principles of any surgical procedure in the treatment of compound fractures. This means adequate and careful preparation of the skin and wound and adequate and careful débridement of devitalized tissues.

I am thoroughly in accord with Doctor Pfeiffer and many other surgeons that antiseptics are of little value in the treatment of lacerated wounds. I also believe that rough handling in the cleansing of wounds with soap and water and occasionally, as was previously advocated, with a scrubbing brush is also deleterious. Careful, painstaking, non-traumatic cleansing is the most important factor in the prevention of infection.

I must confess that I am astonished at the good results presented by Doctor Pfeiffer in his analysis of cases treated by the Orr method. The absence of infection and the absence of secondary operative procedure reveals good surgery carefully carried out. I also believe that he brings out a point which is very valuable in the early skin grafting of these cases; it unquestionably saves the patient weeks of incapacity and also disfiguring scars. Meleney has shown that one may apply pinch grafts within ten days after the removal of a gangrenous slough due to symbiotic infection. I have often wondered whether or not the odor that arises from the Orr treatment is not an indication of the therapeutic value of the therapy. The odor is said to be due to the action of the hay bacilli and other saphrophytic organisms. It is known that if these organisms contaminate a culture medium containing staphylococcus or streptococcus they rapidly overgrow these virulent organisms and cause their destruction. May it not be that the vaseline gauze and the plaster case which cause a good anaerobic medium stimulate the growth of these organisms which digest the offending pathologic bacteria? It has been my impression in treating cases with the Orr method that sometimes dressings are delayed too long for it is noted when they are removed that granulations have penetrated through the meshes of the gauze and considerable trauma is induced in their removal. I can see no harm, after a period of two weeks, in changing the dressing if it seems advisable. I am thoroughly in accord with Doctor Pfeiffer that if this method is started it should be continued through in the same manner unless there is some very strong contraindication. I believe that all of our infected wounds are dressed too often unless treated by the Dakin

method, which should be as described by Carrel—a thorough, non-traumatic cleansing.

In acute appendicitis associated with peritonitis it has been my custom for some time to leave the wound wide open and to pack it with vaseline gauze. This gauze is not disturbed for at least five days, assuming that there is no indication of local infection. The packing is then removed and the wound is again dressed with vaseline gauze inserted lightly. This is not disturbed for a similar period, when the wound is frequently almost healed.

I am thoroughly in accord with Doctor Pfeiffer on his treatment of compound femur fractures. Where the bone is so surrounded by deep muscular structures, it is very difficult to properly apply the Orr method, whether it be in compound fractures or osteomyelitis. I believe the results are as much due to good careful surgery as they are to the method applied.

DR. CALVIN M. SMYTH, JR. (Philadelphia).—The statistical matter in this paper perhaps requires a word of explanation. The majority of the cases in which the Orr treatment was not employed were those seen in the early days of our conversion to the method. As Doctor Pfeiffer said we had been for some time employing open drainage or packing combined with fixation and traction so that encasement in plaster was not such a radical change in our practice.

It has always been difficult to understand the reasoning of those who differentiate between the compounding of a fracture from within out and that from without in, and resting the decision as to immediate closure or open drainage upon this. Certainly, once the bone has protruded through the overlying soft parts and come into contact with the outside influences, contamination has necessarily taken place, and, as Doctor Pfeiffer has said, the matter becomes one of academic interest only. Neither can we who practice surgery in general hospitals receiving street accidents follow with confidence a plan which may work perfectly in a hospital which receives only cases from one or two industrial plants where everything is under perfect control and even the accident itself can almost be made to order. It is for this reason that we are so opposed to the practice of immediate closure.

What the Orr method offers is something which can be carried out in any well conducted hospital by any good general surgeon who will take the trouble to become familiar with the technic and follow it faithfully. We have employed it for a sufficient length of time and a wide enough variety of cases to have complete confidence in the method. We have talked about it in Philadelphia for a number of years and yet we still find a hesitancy on the part of our surgical friends to give it a trial. Curiously enough the most violent objectors to the Orr plan of treatment are found, not among the advocates of open methods, but among those who favor immediate and complete closure, and yet the objection that one hears most is that it is unsafe to leave these patients alone for four or five weeks. It was in the hope that more surgeons might be persuaded to convince themselves regarding the true worth of the procedure that this paper is presented today.

DR. DAMON B. PFEIFFER (Philadelphia).—I hope no one detected a beligerent note in our presentation of this paper, but if so, it comes perhaps from the fact that in spite of our intensity of feeling as to the merits of this method, we have been unable to secure anything like general approval or adoption in Philadelphia.

We presented this paper because we believe thoroughly that the method is a great advance in the treatment of compound fractures. There are three striking things that anyone who has followed this treatment will notice.

In the first place, the uniformity of healing without infection. No other plan with which I am familiar gives us the same security against infection as this procedure.

Second, the strikingly clean and excellent appearance of the granulations which cover bone and soft tissues on removal of the pack.

Third, the rapidity and uniformity with which union occurs in the lower third of the tibia, which is notoriously a site for slow union or non-union. We have yet to have an instance of non-union. As a general rule, union occurs much more rapidly than in ordinary closed fractures.

I have been stimulated to think about the reasons for the efficacy of this treatment, in the first place, because of the incredulity, if I may speak of it, of my colleagues, and in the second place, because one is naturally led to inquire about a phenomenon which is so impressive.

It seems to me, after all, the explanation is quite simple. All of our surgical wounds are contaminated. As surgeons, we must realize that bacteriologic asepsis is a very different thing from surgical asepsis. A Petri dish by the side of your operating table will soon convince you of that fact and while most of the organisms are saprophytes, some have pathogenic possibilities. We actually deal therefore with a dosage of infection, the amount of contamination. We rely upon such factors as blood supply, avoidance of puddling, dead spaces, avoidance of trauma, and we have come to regard our wounds inflicted under aseptic conditions as aseptic because they seem to heal aseptically.

These compound fracture wounds are practically never aseptic, but we reproduce, so far as I can see it in this method, the conditions of a wound inflicted under aseptic conditions. In other words, by débridement, we cut down the amount of infection. By introducing a pack impregnated with vaseline gauze, we prevent the pack from becoming a plug at once so that serum and blood can ooze out and in a very few hours every particle of that wound comes in contact with vaselinized gauze. All crevices are obliterated and complete immobilization is effected.

You have such organisms as are there imprisoned between the gauze and tissues, and the plight of a single or a few organisms in that situation, beset by the serologic and cellular forces of immunity, must be desperate. The wound thus completes its own sterilization. Every little while we have to rediscover the healing powers of nature, and this, I think, is what we are doing in this particular procedure.

BRIEF COMMUNICATIONS AND CASE REPORTS

THE HYPOPHYSIS AND BODY METABOLISM*

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NEW YORK

THE speaker outlined the work now being carried forward at Cornell on the subject of the hypophysis, stating that he presented his first work on this gland before the Philadelphia Academy of Surgery 22 years ago.¹ During this interval it would seem that progress had perhaps been too rapid, when five different hormones have been described as taking origin from two groups of cells; and when a control by this gland is suspected over the four great classes of metabolic activity—fats, proteins, carbohydrates and water—making nine hormones in all. Small wonder that such a control center of the basis of life should be placed in the most inaccessible position of the entire body!

Not only has thinking about the hypophysis become intolerably complex—to these eight or ten hormones is now to be added the concept of separate antihormones—but methods of research have become increasingly difficult, as science advances farther from its old base of supplies, which is still direct observation by the five senses.

In the Department of Physiology at Cornell is one of the few animal calorimeters in existence and with the aid of this machine Doctor Chambers has been studying the problem. The animal is studied day after day, under conditions controlled in respect to all phases of metabolic activity. As a result several definite ideas have thus far been formed, namely:

- (1) After removal of the hypophysis the blood sugar is lowered, and convulsions may occur; but these are not because of the low blood sugar.
- (2) The animal becomes extremely sensitive to insulin, $1/80$ of a unit per kilo being as effective intravenously as $1/4$ of a unit in a control animal.
- (3) This is not because the pancreas contains more insulin than normal, since the operated animal's pancreas contains only the normal amount.
- (4) The belief is growing that the pituitary must be concerned with a process fundamental to general ductless gland action, perhaps with the elaboration of a common mother substance.

A second method of approach to the problem is being attempted by Doctors Richardson and Shorr of the Department of Medicine, who are experts in methods of studying the metabolism of isolated tissues. This work,

* Read before the Joint Meeting of the New York Surgical Society and the Philadelphia Academy of Surgery, February 13, 1935.

though not advanced sufficiently to report results, suggests that the isolated muscle, after combined hypophysectomy and pancreatectomy, is as diabetic as after pancreatectomy alone, even while the entire animal seems less diabetic.



FIG. 1.—Location and extent of skin incision.

A third method in use, and an extremely interesting one, is that which Doctor Anderson of the Department of Anatomy is using in a study of the effect of the loss of specific gland functions upon the conditioned reflexes, using the salivary reflex of Pawlow, and also a conditioned motor reflex.



FIG. 2.—Zygomatic arch and coronoid process of mandible resected, skull trephined.

This method appears to be a sensitive one; an animal without the thyroid completely loses the reflex; it can be restored by thyroid medication, to be lost again on withholding treatment. It seems also to disappear after hypophysectomy, but the effect of medication upon these animals is not yet known.

When complicated and time consuming methods are used, the problem presented to the surgeon becomes somewhat different from what it was with less laborious methods of study. In the first place, the surgeon must do as little harm as possible—a concept fundamental to all surgery but not always sufficiently emphasized—and if an animal is to be studied for weeks or months it becomes of vital importance that the experimenter may know at the time of operation just what happened, not have to wait until serial sections of the brain base may disclose, after weeks of labor, that the gland was incompletely removed. Doctor Sweet said that this was his special problem and thought it might be of interest to surgeons to see how it has been successfully met.

The method of approach to the pituitary is the same as was previously described¹ (Fig. 1). An incision about two inches in length is made perpendicularly over the zygoma. The zygomatic arch is removed by sub-

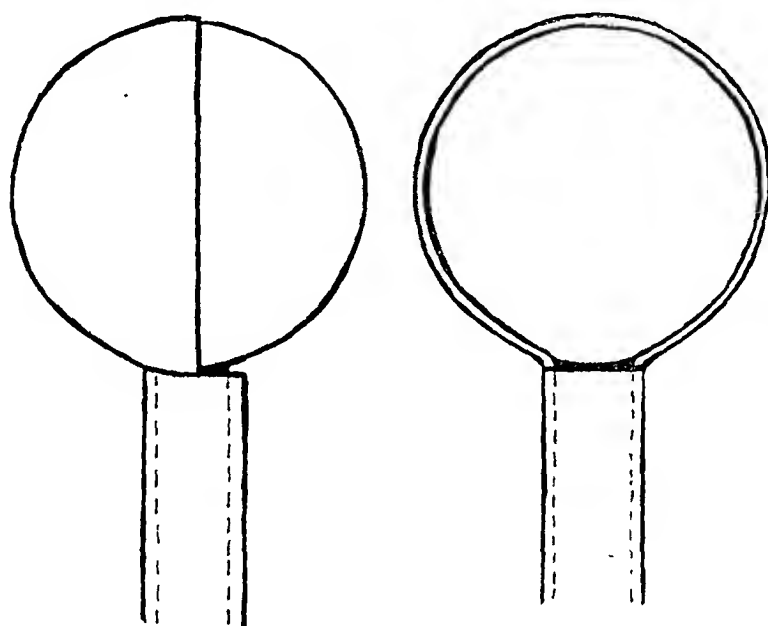


FIG. 3.—Schematic drawing of double spoon.

periosteal resection. The coronoid process of the mandible is resected and the skull approached in a direct line, as near as possible to the base. The skull is trephined and the hole somewhat enlarged (Fig. 2). The dura is removed and the brain slightly elevated by a suitable retractor, the best retractor in his experience having a short blade with carefully rounded edges, fastened to the end of a bronchoscopic light carrier. An adjustable hand piece is attached to the retractor for ease in holding (Fig. 4). The removal of the hypophysis is accomplished with the aid of a double spoon or curette (Fig. 3). A hemispherical spoon of proper size to hold the pituitary is fitted to a slightly larger spoon which revolves over the inner spoon. With the device open it is gently introduced above and posterior to the gland; the edge of the spoon is then inserted underneath the pituitary, thus severing the attachments of the posterior lobe, and is turned so that the gland lies within the inner spoon. While the operator holds it in this position the assistant rotates

the outer spoon, severing the stalk and permitting the withdrawal of the gland intact and *in toto*. Figure 4 shows the retractor, the double spoon closed, and in the middle a single spoon which is sometimes used to free the attachments of the posterior lobe.

The main object of the procedure—to enable the operator to demonstrate at the close of the operation whether the gland has been completely removed—is thus successfully met.

REFERENCE

- ¹ Sweet, J. E., and Allen, A. R.: The Effect of the Removal of the Hypophysis in the Dog. *ANNALS OF SURGERY*, April, 1913.

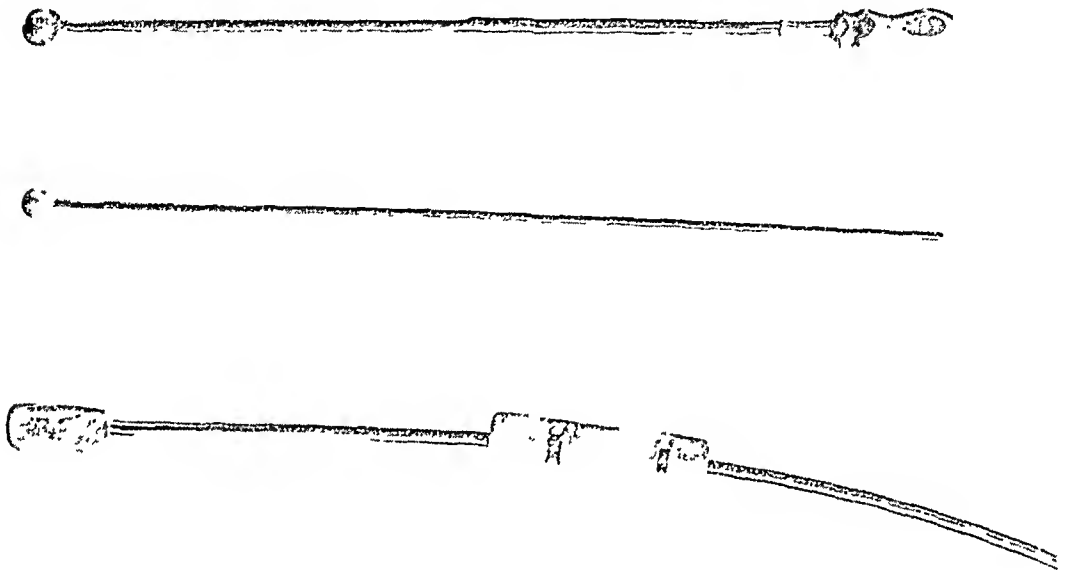


FIG. 4.—The double spoon. A single spoon. The lighted retractor.

DISCUSSION.—DR. ISIDOR S. RAVDIN (Philadelphia) felt that although developments in the field of pituitary physiology may have been too rapid, nevertheless it is to be assumed that with the method developed by Doctor Sweet and the group now associated with him, advancement will be even more rapid than in the past.

Houssay and his associates have demonstrated clearly the relationship between the pituitary, adrenals, and pancreas, and have shown clearly the complexity of the problem of carbohydrate metabolism. Recently, Long and Lukens have made noteworthy contributions and the recent studies of Fluch, Greiner and Loewi have added considerably to this field, the foundation of which was laid by Cushing.

Emery and Atwell have demonstrated that the injection of an extract of the whole pituitary results in a marked increase in the weight of the adrenals and similarly it has been shown that hypophysectomy causes a decrease in the weight of the adrenals and thyroid.

Melville and Holman have shown that the diuretic action of the posterior

SPINAL ROOT FOR HYPERTENSION

lobe extract is in the pressor fraction, the oxytocic fraction having a diuretic action only 5 per cent as great as the pressor fraction. Black, Collip and Thompson demonstrated that suitable anterior pituitary extracts greatly increase the acetoneuria in rats. This ketogenic principle is not identical with the thyreotropic, adrenotropic or the growth hormone.

The recent experiments of Targow confirm and extend the earlier investigations of Evans and others in that they show that the growth promoting extract of the anterior lobe causes (1) a decrease in the weight of the pituitary gland; (2) an increase in the nose-anus length; (3) an increase in the weight of the heart, lungs and kidneys; and (4) an increase in the water content of the skin and kidneys.

The close relation of the pituitary with the thyroid has been amply demonstrated. Any gland that has (1) pressor; (2) oxytocic; (3) growth stimulating; (4) thyreotropic; (5) adrenotropic; (6) gonadotropic; and (7) diuretic substance and perhaps others with which we are not as yet familiar, justly deserves the extensive series of studies which Doctor Sweet and his associates propose.

ANTERIOR SPINAL NERVE ROOT SECTION*

A SURGICAL TREATMENT OF ESSENTIAL HYPERTENSION

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ESSENTIAL hypertension is a disease as yet not clearly understood, the medical treatment of which has thus far proven unsatisfactory. In view of the tragic future to which individuals affected with this disease must look it had seemed proper to approach its treatment by the more radical methods of surgery. Dr. Irving H. Page of the Hospital of the Rockefeller Institute for Medical Research and Doctor Heuer had been interested in these surgical methods for some time. He wished to refer to only one surgical method in the treatment of this disease—that of anterior spinal nerve root section.

This procedure is based in part upon the physiologic observations of J. Rose Bradford published in 1889 to the effect that stimulation of the anterior roots of the spinal nerves from the sixth dorsal to the second lumbar causes a rise in blood pressure and contraction of the kidney, the greatest result being obtained by stimulation of the anterior roots of the tenth dorsal to the first lumbar. This and other evidence would indicate that the arterioles of the splanchnic area are constricted in patients with essential hypertension and that more or less maintained vasoconstriction may be an important factor in keeping the pressure at a high level. Interruption, by surgical

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means, of nerves carrying effector impulses to this area would, therefore, appear to be a logical therapeutic measure.

The operation consists in the division of the anterior roots of the spinal nerves within the field covered by the sixth dorsal to the second lumbar. In only one instance were all the anterior nerve roots divided from the sixth dorsal to the second lumbar. In the remaining cases, a lesser number were divided (Table I).

TABLE I

Patient	Initial Blood Pressure	Postoperative Blood Pressure		Roots Sectioned
		1 mo. P.O.	3 or more mos. P.O.	
I. S. (63717).....	192/120	130/82	124/92	6 T- 2 L
R. H. (82044).....	180/118	136/90	122/80	9 T- 1 L
B. H. (80474).....	218/138	146/94	140/92	9 T- 1 L
P. S. (78618).....	200/118	140/100	142/100	9 T- 1 L
A. S. (78647).....	220/144	120/80	144/94	9 T- 1 L
A. R. (84842).....	220/130	120/82	..	8 T-12 T
F. S. (85648).....	210/124	160/105	..	7 T-12 T
J. A. (80439)*.....	240/160	230/120	246/140	9 T-12 T
F. D. (68407)†.....	240/160			

* Died four months after operation.

† Died at end of operation.

A laminectomy is done, the dura opened and the anterior nerve roots exposed by gentle rotation of the cord. Each pair of nerves is divided between ligatures of fine silk. The operation, a delicate procedure, must be performed with great attention to detail.

The first operation of this nature performed by Doctors Heuer and Page was on May 11, 1934. At that time only one case operated upon by this method had been reported, that of Adson and Brown. Their result led to the selection of patients for operation who, so far as could be determined, did not have structural changes in their blood vessels.

Thus far in this series nine patients have been operated upon. Two had advanced disease and did not conform to the postulate that cases selected for operation should be early cases. One, a serious surgical risk, died at the completion of the operation. The second, also a serious risk with advanced disease, did so badly that the operation was abandoned after the division of the ninth to the twelfth thoracic nerves. His blood pressure was not affected following operation and he died four months later from his disease. The remaining seven patients have done well and their blood pressures have been reduced to normal or almost so (Table I).

The disabilities to be expected after operation thus far have not been serious. The difficulty in evacuating the bladder and bowel observed within 24 to 48 hours after operation promptly disappeared. The paralysis of the abdominal muscles apparently has been of little consequence, and other

demonstrable changes the result of root section have not affected the patients detrimentally.

DISCUSSION.—DR. FRANCIS C. GRANT (Philadelphia) said that his experience with surgical methods for reducing hypertension had been limited to a single case. When the Neurosurgical Society met at Ann Arbor in 1934 Doctor Peet, who, with Doctor Kahn had been attacking this problem, reported success with section of the middle and lesser splanchnic nerves. This procedure appealed to Doctor Grant more than the operation described by Doctor Heuer. Laminectomy he felt to be objectionable, first on the ground of magnitude, and also for the reason that the roots are tied off without separating them from the very fine anterior spinal blood vessels that run with them, so that interference with the blood supply of the cord may result in a paraplegia. In one of the first cases in which laminectomy and anterior root section was performed at the Mayo clinic, partial paraplegia did follow.

CASE REPORT

About a year ago a colored man, 40 years of age, was admitted to the Graduate Hospital, Philadelphia, suffering from headache and loss of vision. His blood pressure was 240/190. He had a choked disk of four diopters but no localizing neurologic symptoms. The urine was entirely negative and the blood urea within normal limits. He was moderately arteriosclerotic. We had no suggestions to make regarding treatment unless he would permit section of his splanchnic nerves. He consented, whereupon the tenth rib on the left side was resected, the middle and lesser splanchnic nerves were sectioned and also his thoracic sympathetic chain including the ninth, tenth and eleventh ganglia.

The result was rather striking. After ten days' preoperative rest in bed, during which time the blood pressure fell to 190/140, after operation to 130/100, averaging 140/100 for three weeks, at one point it fell to 110/85. An empyema then developed, during which the blood pressure rose at one time to 170/140, but following evacuation of the pus it fell again. During the four months since then it has maintained a level of 120 to 140/90. The Fishberg test has remained entirely negative, the blood urea has been within normal limits and urinary concentration has been maintained. The patient's headache was completely relieved during the first ten days following operation and recession of the choked disk, which began two weeks after operation, was complete within six weeks.

At the follow up clinic March 9, 1935, one year postoperative, his blood pressure was 180/130. He no longer had headache and there was no choking of the disks. A routine urinary examination was negative. Specific gravity 1.020, no albumin and no casts. It would seem, therefore, that reduction in the blood pressure following section of splanchnic nerves and thoracic sympathetic chain from the ninth to the twelfth ganglia on the left side—only temporarily effected a reduction of blood pressure. However, the headache has been relieved, the disks have remained flat and as yet there are no urinary findings suggesting the presence of chronic nephritis.

Doctor Grant said he had no explanation to offer for the effect of this operative procedure. Doctor Fay at Temple University has produced evidence to suggest that the blood pressure control mechanism is situated somewhere between the eighth to the eleventh thoracic segments. It is the sympathetic pathways from these particular segments that are sectioned together

with the middle and lesser splanchnic nerves. If further experience confirms the reduction in blood pressure produced by this operation in this case, the surgical procedure is certainly easier than the extensive laminectomy advocated by Doctor Heuer. Doctor Peet has reported six cases, in four of whom the operation was successful, with improvement in the two remaining instances.

LOBECTOMY FOR BRONCHIECTASIS *

REPORT OF FOUR CASES IN CHILDREN

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THE children presented were admitted to the Bellevue Medical Service for Children where they not only had a diagnostic "work up," but were treated by all conservative means including bed rest, long periods of postural and bronchoscopic drainage. Their symptoms were ameliorated but there was no abatement or retrogression of the lesions. Radical procedure for the removal of the diseased portion of the lung was determined upon.

All four patients gave a history of frequent recurrent pneumonia. All had profuse, malodorous, mucopurulent expectoration, the amounts varying from a few ounces up to 30 ounces in 24 hours. Loss of appetite and sleeplessness were general complaints. Ostracism from school and society was complained of by both patients and parents.

Two of the children had developed empyema following attacks of pneumonia, and both had been operated upon for this complication. The third patient had a definite lung abscess following a tonsillectomy and the fourth had spent two years in a tubercular sanatorium for "lung trouble."

Physically all were underdeveloped, anemic and apparently chronically ill. All had clubbing of the fingers in varying degree. Various physical signs could be elicited by auscultation of the chest, depending upon the amount of retained secretion at the time of examination. All were bronchoscoped and mucopus aspirated from the main bronchus of the lobes involved. No foreign bodies were found in the bronchi during bronchoscopy. Roentgen ray examination revealed fibrosis of the involved lobes with a tendency of the mediastinum to shift toward the involved side.

CASE REPORTS

CASE I.—A. B., a boy of nine years, was operated on February 10, 1932. Due to numerous preceding illnesses, including an attack of acute hemorrhagic nephritis, he was a poor operative risk. His left lower lobe, which was to be removed, was found adherent to the chest wall, diaphragm, pericardium, and to the upper lobe. It was bluish black in color, small in size, and atelectatic. The operation was done in two stages. The postoperative course was stormy, and included an attack of scarlet fever,

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LOBECTOMY FOR BRONCHIECTASIS

but at no time was the patient in a serious surgical condition. Since his discharge from the hospital he has been cough and sputum free, has developed normally, and his general health is much improved. The clubbing of the fingers has not resolved and he has had one attack of nephritis.

In 1934 he was readmitted to the hospital on account of a small sinus in the middle of his scar which proved to be a bronchocutaneous fistula, developing two years after operation. A muscle plasty operation was done, the fistula has remained closed and the patient is in good health.

CASE II.—F. I., a boy of seven years, was operated upon October 1, 1932. A lung abscess of the right middle lobe following tonsillectomy was the origin of his bronchiectasis, which invaded the entire middle and a portion of the lower lobe.

The two lower lobes were removed *en masse* in a two stage operation. He has remained well since his discharge from the hospital, developing normally in every way, and is able to attend a general school. His chest shows no clinical deformity.

CASE III.—F. A., a girl of 11 years, was operated upon by a two stage lobectomy January 10, 1934. She had large multiple bronchiectatic abscesses of the left lower lobe and would expectorate 30 ounces of sputum in 24 hours. Her temperature ranged between normal and 101°, regardless of bed rest, postural and bronchoscopic drainage, which increased the hazard of lobectomy. After freeing the lower lobe from adhesions, her condition would not permit further surgery, thus necessitating a two stage operation. During a 19 day interval, adhesions reformed and were so dense that at operation only two-thirds of the lobe could be freed. This portion was resected and the balance removed by the use of actual cautery. A bronchocutaneous fistula formed, which has been kept open and is draining considerable mucoid material. The patient is now in excellent physical condition and is cough and sputum free. She is to be operated on again for removal of the small portion of diseased lung that is apparently responsible for the present discharging fistula. Cautery pneumonectomy has not proven very satisfactory in this case, and obviously should be used only when other means of removal are impossible.

CASE IV.—H. S., a girl of 11 years, was operated on April 10, 1934, for a left lower lobectomy. The entire lung was involved and a pneumonectomy was contemplated. However, since the greatest involvement was confined to the lower lobe, it was removed in a one stage operation. (The remaining lobe is to be removed at a later period.) Her convalescence was short and uneventful. She has become cough and sputum free, and for this reason the upper lobe has not as yet been removed. She is in excellent condition.

Lobectomy is a radical procedure and, of necessity, has considerable mortality, although these four consecutive cases have survived. It is not advocated for all cases of bronchiectasis in children but should be considered in cases with extensive pathology where most of the lung tissue has been destroyed, leaving only a shrunken, fibrosed portion of lung composed of dilated bronchi and multiple bronchiectatic abscesses. If early diagnosis of bronchiectasis can be made and if cases tending to retrogress be differentiated with certainty from those that tend to progress, the operation may be done before adhesions form and before the general condition of the patient deteriorates as the result of long suppuration. This would greatly reduce the mortality.

Many more lobectomies have been done on adult patients than on children, although 50 per cent of the adult patients date the genesis of their disease to childhood. This procrastination is not justified because:

- (1) Children withstand the shock of lobectomy as well as, or better than adults.
- (2) The tissues are more elastic during childhood.
- (3) Due to growth, the anatomic deformities caused by the operation are reduced.
- (4) Many patients die from the disease before reaching adult life.
- (5) The disease often becomes more extensive, both by extension to other lobes and by the formation of adhesions to surrounding viscera.
- (6) By curing the disease, these little patients are no longer ostracized from school and society.

DISCUSSION.—DR. GEORGE P. MULLER (Philadelphia) demonstrated two extremes in the technical procedure of lobectomy by referring to two cases. The first was a child of six years who at the age of two and one-half years aspirated a peanut following which he had chest pain and cough. Doctor Clerf removed the foreign body through the bronchoscope and the child remained well except for some cough until 14 months ago when he had an attack of measles, after which symptoms became more severe and he had expectoration and hemoptysis. He was treated bronchoscopically by Doctor Clerf, but early in December it was decided a lobectomy would be necessary. Doctor Muller operated in January, removing the left lower lobe. This was done in one stage through a posterior incision, using avertin and nitrous oxide-oxygen anesthesia. A small catheter was introduced through a lower separate stab and attached to a low pressure suction machine. There were so few adhesions at the approach to the hilus that this was quite easy, and as it was possible, by increased pressure in the mask, to blow the lung down there seemed no reason not to conclude the operation in one stage. The child made a perfect recovery. Roentgenograms show that the upper lobe completely fills the left chest. This represents the ideal case: bronchiectasis of one lobe treated by careful palliative measures and then by lobectomy in one stage followed by perfect healing.

Of an entirely different type is the story of a girl 12 years old who had an empyema that was operated upon several times before she was seen by the speaker. A small bronchial fistula was present and she was coughing with profuse expectoration. Because there was multiple cavitation as well as bronchiectasis, operation was begun with the intention of doing a Graham cautery excision. However, after exposure, it seemed proper to remove the lower lobe, which was done. Unfortunately, the disease was also in the middle and perhaps in the base of the upper lobe. Consequently, while the child improved greatly clinically, nevertheless lipiodol injection shows that she has a large degree of bronchiectasis in the parts mentioned. Therefore, there remains nothing other than total removal, or removal of the middle and part of the upper lobe.

MULTIPLE CARCINOMATA OF THE COLON *

PARTIAL COLECTOMY FOR CARCINOMA OF THE TRANSVERSE COLON (1920);
OF THE SIGMOID (1926) AND OF THE ASCENDING COLON (1934)

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CASE REPORT.—A female, 43 years of age, was first treated 15 years ago at the age of 28 because of vague, right, lower abdominal pain, occasionally located in the right flank, which bore no relation to meals and was generally unattended by other symptoms referable to the gastro-intestinal tract. There was no nausea, vomiting or diarrhea. On physical examination a movable kidney could be palpated and the late Dr. A. V. Moschcowitz, who thought her symptoms could be ascribed to chronic appendicitis, decided to do a nephropexy and through the same incision explore the appendix. Under gas-oxygen-ether anesthesia an abdominal exploration revealed the presence of a mass in the region of the transverse colon. Through a separate abdominal incision this mass was found to consist of an intrinsic neoplasm of the colon and was

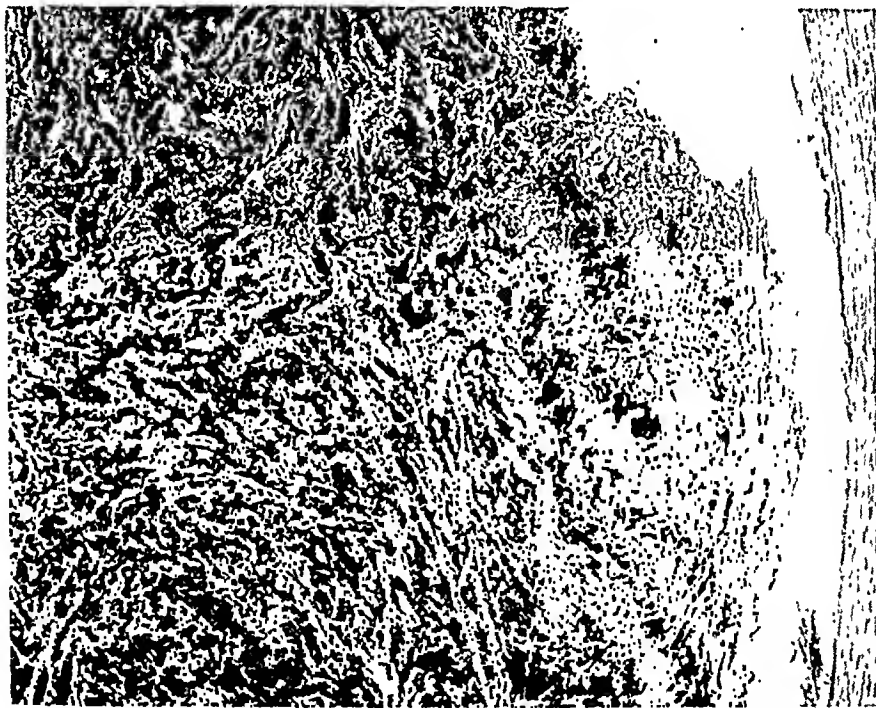


FIG. 1.—Photomicrograph of adenocarcinoma removed from transverse colon, 1920.

accordingly resected with an end-to-end anastomosis. The patient made an uneventful recovery. The specimen removed consisted of a portion of the large intestine, measuring about 10 cm. in length, and presented an ulcerated carcinoma occupying the entire circumference of the gut. The tumor presented a heaped-up cauliflower margin with its center ulcerated and necrotic. The gross and microscopic diagnosis was adenocarcinoma (Fig. 1).

The patient was entirely symptom free until five years later (1925) when she was readmitted to Mt. Sinai Hospital with a history of dull, left lower abdominal pain, attended by some weight loss. Physical examination was entirely negative except for evidences of her previous laparotomy and nephropexy. A vague mass could be felt on vaginal examination in the left fornix and was interpreted as either ovarian or sigmoidal in origin. Proctoscopy with biopsy was reported as showing necrotic colloid

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material and rectal mucosa containing pigment but with no distinct evidence of neoplasm. Exploratory laparotomy again by Doctor Moschowitz through a left, lower, muscle splitting incision under the presumptive diagnosis of either an ovarian or sigmoidal

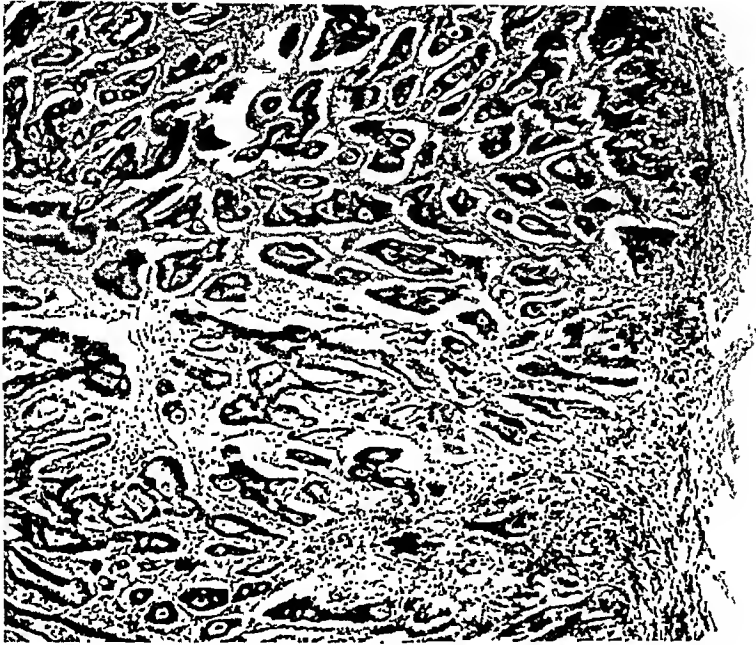


FIG. 2.—Photomicrograph of adenocarcinoma of sigmoid resected in 1925.

mass revealed a firm tumor involving the upper portion of the sigmoid flexure of the colon. Further exploration showed no liver metastases and palpation of the transverse colon region was negative. A resection of the involved flexure was done between

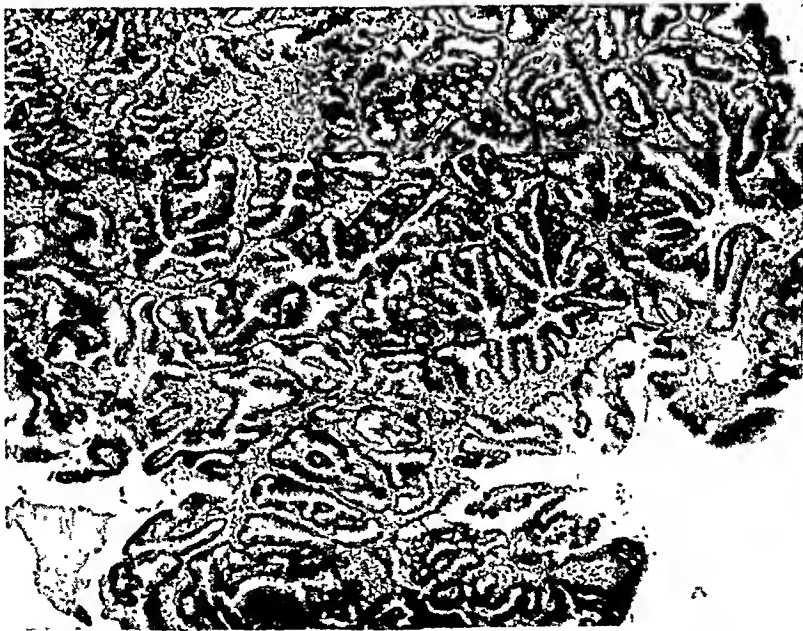


FIG. 3.—Photomicrograph of adenocarcinoma of uterus, 1928.

clamps and an end-to-end anastomosis established, with drainage. Her postoperative course was complicated and prolonged by a fecal fistula and a pelvic exudate. She was discharged, well, one month and a half after operation. The resected specimen of sigmoid was 6 cm. in length. The entire wall of the sigmoid was involved in an annular

MULTIPLE CARCINOMATA OF THE COLON

growth and the serosa was scarred and puckered. On section, it presented a rather flat, papillary growth about 5 cm. in diameter occupying the entire circumference of the bowel. The intestinal wall beyond the tumor presented a peculiar, pigmented condition. The attached portion of the mesosigmoid contained a few small lymph nodes. Pathologic diagnosis was adenocarcinoma without lymph node involvement (Fig. 2).

Three years later (1928), she was readmitted to Mt. Sinai Hospital on the service of Dr. Robert T. Frank for irregular uterine bleeding of six weeks' duration. Abdominal examination was negative. Vaginal examination disclosed a large, firm, and slightly irregular uterus which was retroflexed. Diagnostic curettage revealed the presence of an adenocarcinoma of the uterus (Fig. 3). A complete hysterectomy and bilateral salpingo-oophorectomy was done by Doctor Frank. A small area in the right fundal



FIG. 4.



FIG. 5.

FIG. 4—Barium enema showing filling defect in ascending colon

FIG. 5—Photograph of resected colon (1934) showing melanosis of mucous membrane. The carcinoma stands out as the white object in the dark background. Not all of the resected colon is included in this photograph.

wall was the seat of the malignancy. There was no evidence at this time of any recurrence in the sigmoid. The patient made an uneventful convalescence and was discharged 21 days after admission.

She was perfectly well for a six year interval and consulted me in January, 1934, for a very minor surgical condition. Interested in her previous surgical experiences on inquiry she admitted reluctantly that again she had had some vague abdominal pain, fleeting in nature and not very severe, for the previous three weeks. Examination revealed some tenderness in the right lower quadrant and the vague suggestion of a mass. Barium enema revealed the presence of a filling defect in the midascending colon (Fig. 4).

Pelvic and rectal examinations were entirely negative and the patient was again advised operation. She was readmitted to Mt. Sinai Hospital on the service of Dr. Richard Lewisohn and operated upon by me. Under general anesthesia, through a right midrectus incision, a stenosing, circular, carcinomatous lesion of the ascending

colon was found. The adhesions, as the result of previous laparotomies, were dense. Palpation of the pelvis and liver were negative. An ileocolic resection of the terminal ileum, ascending colon, and a large portion of the transverse colon, almost to the splenic flexure, was done with side-to-side suture ileocolostomy. A larger portion of the transverse colon was resected than would ordinarily have been necessary because of the vascular arrangement which was irregularly disturbed by the previous resection in this area. Patient made an uneventful convalescence.

The specimen consisted of a small piece of terminal ileum and 25 cm. of cecum, ascending, and a portion of the transverse colon (Fig. 5). At a point in the ascending colon, 5 cm. from the ileocecal valve, there was present an annular, constricting, infiltrating, granular, hard, necrotic tumor, measuring 3 cm. in length along the longitudinal aspect of the gut, necrotic in its center, infiltrating all the coats of the intestine at this point, and invading the fat around it. The mucosa of the entire portion of the resected colon had a greenish black appearance. The mucosa was freely movable except

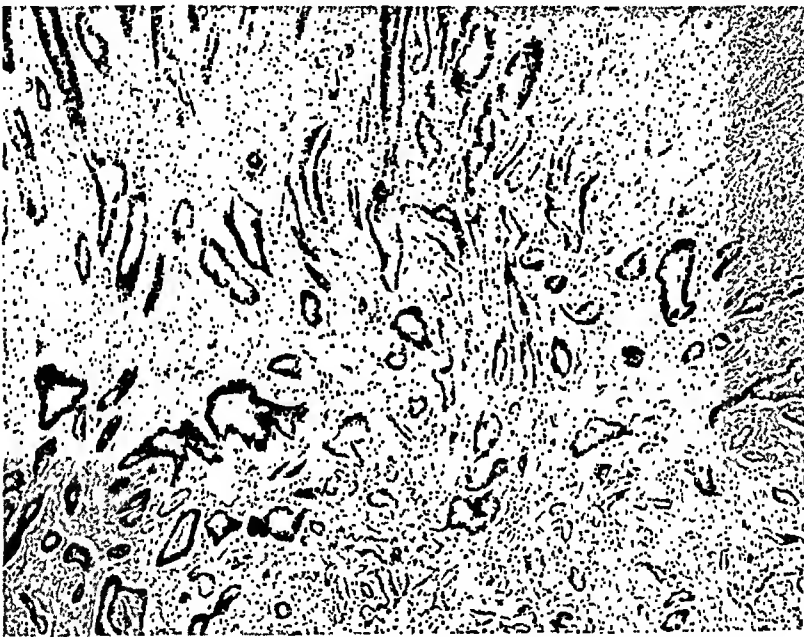


FIG. 6.—Photomicrograph of adenocarcinoma of ascending colon resected in 1934.

over the region of the tumor described. There were many nodes in the mesentery which appeared enlarged. Melanosis appeared universally in the part of the intestine resected except in the ileum and the portion of the colon that was involved by the carcinoma. Pathologic report: adenocarcinoma and melanosis of the colon (Fig. 6). Lymph nodes uninvolved.

The patient made an uneventful recovery. It is now one year since her last operation and 15 years since her first of the series of intestinal resections. Barium enema, one week ago, showed a normally functioning stoma with a normally outlined colon up to the point of resection (Fig. 7).

I shall not discuss, because of time limitation, the fascinating subject of multiple, primary, malignant new growths in the same patient because, whether we hold the colonic neoplasms successively removed to be all primary tumors or not, the patient presents, in addition, an independent new growth of an entirely different organ.

A cursory review of the literature shows that multiple carcinomata of

the gastro-intestinal tract, while far from rare (169 cases were collected by Warren and Gates¹), only 29 of these are limited to the colon. Barga and Rankin² contribute the largest group of cases in the literature. One of these corresponds closely to the patient under discussion. A cancer of the ascending colon was resected in 1920; in 1926, carcinoma of the sigmoid was resected; in 1929, a third growth was found in the splenic flexure and removed, while in the same year hysterectomy was done for sarcoma of the uterus. Dowden³ (1917) reported a case in which four metachronous cancers of the colon developed in six years. Lilienthal⁴ has recorded a case in which the subsequent tumor developed 20 years after the extirpation of the first and



FIG. 7.—Barium enema taken in 1935 showing a normal colon up to the point of resection and a normally functioning stoma.

in an entirely remote portion of the colon. At Mt. Sinai Hospital, we have encountered a number of synchronous carcinomata of the colon. Doctor Lewisohn⁵ reoperated upon a patient six years after the first colonic tumor was excised for an apparently independent new growth.

That preexisting adenomatous polyposis is a very definite etiologic factor in the development of multiple colonic cancers is known. There is no evidence that this etiologic factor is present in this case. When two or more cancers are found in the intestine the first and most obvious explanation is that one is the primary growth and the others are secondary implantations. This argument is not always admissible because either the most distal growth is the oldest or the growths are too far apart, or the interval between the appearance of the growths is too long. It would seem that the time interval

between the appearance of the growths in this patient and the absence of metastases would lead one to consider these tumors as independent new growths.

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DISCUSSION.—DR. DAMON B. PFEIFFER (Philadelphia) stated that this case of successive, independent carcinomata was unique as far as his personal experience went. The nearest approach that he had had concerned a woman of 35, operated upon in 1916 for a carcinoma of the right breast. A radical operation was done and metastases found in the axillary nodes. She remained well except for a swollen arm until 1920 when a small lump appeared in the left breast. This was removed and found to be a benign adenofibroma. In 1929, another adenofibroma was removed from the same breast. In 1931, another lump appeared which proved to be a carcinoma and a radical operation was performed. As 15 years had elapsed and there was no evidence of carcinoma elsewhere, and as all appearances pointed toward the second carcinoma being an independent growth and not a metastasis, Doctor Pfeiffer believed that it was truly independent. The following year she noticed a small lump in the left lobe of the thyroid. She was rather toxic and nervous, though her basal metabolism was normal. In view of her history, operation was recommended and the greater part of the lobe containing the nodule, which was about the size of a small acorn, was removed. It was imbedded in the lower pole and microscopic examination showed it to be a carcinoma which at some points was invading the blood vessels. Under treatment with roentgen ray the patient has remained well. Her sister, much older, had a carcinoma of the breast removed 35 years ago and has remained well.

Doctor Pfeiffer went on to say that he had had several cases of simultaneous carcinomata. One was a woman upon whom he operated in 1932 for recurrent appendicitis. Incidentally at exploration a papillary cyst carcinoma of the right ovary, about three inches in diameter, was found. It had perforated the wall and involved the cellular tissues of the pelvis. Feeling certain that recurrence would take place and with the view of giving her the most effective radiation, he placed a capsule of radium in her uterus. She remained well for two years and then began to bleed from the uterus. Curettement showed adenocarcinoma of the fundus. Hysterectomy was car-

ried out. It was interesting that at operation there was no trace of the original carcinoma of the ovary. The peritoneum was clear and the tissues of the pelvis were entirely uninvolved.

Last year he saw a case of carcinoma of the rectum evidently primary which followed carcinoma of the uterus in 1927, and had at present in Lanke-nau Hospital a man operated upon in January for palpable carcinoma of the descending colon who showed on exploration an additional carcinoma of the rectosigmoid. There was at least one foot of bowel intervening between the two growths and no demonstrable metastases from either. The carcinoma of the descending colon was removed at the first sitting, the distal loop was closed, and at the second stage the remaining growth was removed by an abdominoperineal operation. The laboratory reported no glandular meta-stases. Two other cases of simultaneous carcinoma of the rectum and sig-moid, apparently independent had also been seen. Neither showed polyposis, although there were a few discrete polyps in one of them.

Such cases, in the absence of knowledge as to the etiology of the malignancy, cause one to speculate as to the possibility of either individual pre-disposition to malignant disease or the presence of some causative factor, or both. Such common diseases as carcinoma necessarily present many coinci-dences. Dr. William H. Welch, in combating the idea that cancer was an infective disease, pointed out that the argument based on so called cancer houses, domiciles in which many cases of cancer had occurred, could be ac-counted for on the basis of the extraordinary prevalence of cancer. Could such cases of multiple carcinomata as Doctor Klingenstein has reported be simply the result of the mathematical probabilities? Warren and Gates in the American Journal of Cancer, 1932, on the basis of 1,259 collected cases of multiple malignancy came to the conclusion that such conditions occur more frequently than can be explained on the basis of chance. There is a growing conviction that there is some factor in the individual that makes him more susceptible to the development of malignant disease and this de-rives support from the fact that in the experimental production of cancer by carcinogenic agents, it is only in a certain proportion of animals that malig-nant disease can be produced.

It is interesting that certain tissues are predisposed to multiple malignancy. Skin leads in this respect, and the colon is second. Cokkinis in the British Journal of Surgery 1934 reported a case which showed four simultaneous carcinomata of the descending colon, appearances indicating that all were independent. Bargen and Rankin reported a case of three successive car-cinomata of the colon followed by sarcoma of the uterus. Doctor Pfeiffer considered it remarkable that the stomach, the most frequent seat of cancer in the body, has never been reported, to his knowledge, as a seat of succes-sive or simultaneous cancers. General polyposis of the colon is hereditary and practically always ends in cancer of that organ. A collection of cases of this sort might be important in enlarging our knowledge of the nature of cancer.

THE ANORECTAL PHASE OF LYMPHOGRANULOMA INGUINALE

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THE object of this contribution is to stress the incidence in this part of the country of lymphogranuloma inguinale. This disease has long been considered peculiar to the tropics, where it has been thoroughly observed and fully described as climatic bubo.¹ Frei² reported an intradermal test for lymphogranuloma inguinale in 1925, and since then many reports of this condition have come from Europe, South America, and the United States.

In 1932, DeWolf and Van Cleve¹ made the first complete report in this country, and chose the designation "Lymphogranuloma Inguinale." A month later Sulzberger and Wise³ described this syndrome under the title "Lymphopathia Venereum." The following year Cole⁴ wrote an article on the relation of this disease to rectal stricture. He called it the "Fourth Venereal Disease."

Lymphogranuloma inguinale is a specific venereal disease caused by a filtrable virus. The initial lesion is small and evanescent, and occurs on the penis in males, and within the vagina in females. Ten days to three weeks following exposure, the draining lymph nodes enlarge. In the male, because of the location of the primary lesion, the superficial inguinal nodes become involved and eventually suppurate; secondary pelvic involvement may occur. In the female, however, the location of the primary lesion causes the deep pelvic nodes as well as the nodes surrounding the rectum to become involved; inguinal localization is rare. The perirectal involvement produces obliterating inflammatory rectal strictures, usually accompanied by peri-anal elephantiasis and often complicated with multiple fistulae. The most serious sequela of this disease is rectal stricture.

The anorectal phase of this disease has been confused with syphilis, tuberculosis, gonorrhea, and malignancy, but the diagnosis has been greatly simplified by the Frei test which consists of the intradermal injection of 0.1 cc. of antigen prepared from an uncomplicated node in a known case of lymphogranuloma inguinale. The duration of the disease in our cases averaged about 18 years, causing us to agree with others^{1, 4} that the skin reaction probably lasts indefinitely.

The remedies suggested for the treatment of this condition are many but reports of their efficacy vary. No specific has been reported. It is generally agreed that the sequelae of lymphogranuloma inguinale, such as rectal stricture and peri-anal elephantiasis, cannot be expected to respond to any other treatment but surgery.

CASE REPORTS

CASE I.—Mrs. C. S., aged 49, white, a housewife, was admitted to the Brooklyn Hospital, May 24, 1934, complaining of general malaise, difficult defecation, and fever.

For about 20 years she had had difficulty with bowel movements, obtaining evacua-

tions only with enemata and saline cathartics. Fifteen years ago a rectal dilatation was done under a general anesthetic. This gave her temporary relief.

For two weeks preceding her admission to the hospital, there had been increased constipation accompanied by general malaise and afternoon fever. She experienced increasing difficulty in introducing the rectal tube. There had been occasional spotting of blood, but no diarrhea and no urinary disturbances.

Examination.—The patient was emaciated, moderately dehydrated, her mucous membranes were anemic, and her tongue dry and furred. Blood pressure 110/80. Urine, normal. Blood Wassermann, negative. The blood count showed a marked secondary anemia.

On abdominal examination the sigmoid was easily palpable and distinctly distended. There was no tenderness. Anorectal examination revealed a fistula in the left posterior peri-anal region. On digital examination an obstruction was encountered $3\frac{1}{2}$ cm. from the anal opening. On proctoscopic examination the obstruction was found to be a rectal stricture 5 Mm. in diameter.

Frei tests done on admission and five days later were both positive.

Operation.—Under spinal anesthesia, 50 mg. of procaine hydrochloride being used, excision of the fistula, and posterior proctotomy were performed May 25. Biopsy was taken. A blood transfusion was done.

Pathologic Report.—Sections show no rectal wall identifiable as such. There is a chronic inflammatory process involving fibromuscular tissue with formations of foreign body type nodules in the fat. The inflammatory process does not appear to have any distinctive features.

Postoperative Course.—The postoperative course was uneventful. The wound was irrigated with acriflavine 1 to 1,000 and dressed daily. The bowels moved on the third postoperative day and regularly thereafter. The patient was discharged from the hospital ten days after operation with the wound in good condition. She was perfectly comfortable and able to attend to her duties until February 16, 1935 (nine months after discharge from the hospital) at which time she reentered the hospital complaining of copious rectal bleeding of sudden onset of 16 hours' duration.

Proctoscopy showed that the previously described rectal involvement was in better condition than at the time of discharge from the hospital, *i.e.*, the lumen was large enough to permit easy evacuations and there was no evidence of infection. Above this area, however, there was new involvement which extended into the sigmoid which bled easily. The sigmoid and rectum were packed with iodoform gauze which was removed in 24 hours. There was no further bleeding.

The blood showed a moderate secondary anemia for which she was given a transfusion of 500 cc. of blood.

In view of the nature of the disease, the new involvement, and the probability of recurrent hemorrhages, it was thought advisable to perform a colostomy.

Operation.—February 18, under spinal anesthesia, using 100 mg. of procaine hydrochloride, a permanent colostomy was performed.

Postoperative Course.—The colostomy was not opened until February 28, at which time the abdominal wound was perfectly healed. She was discharged March 16, and has done well thus far.

CASE II.—Mrs. A. G., aged 43, white, a housewife, was admitted to the Brooklyn Hospital, August 11, 1934, complaining of pain in the left lower quadrant of the abdomen, constipation, nausea and vomiting, and blood in stool.

She stated that for 18 or 20 years she had been markedly constipated, and for the last two years there were periods when she would not have an evacuation for 12 to 15 days at a time. Toward the end of these attacks she would have marked sense of fulness in the epigastrium. With an eventual evacuation she would be quite comfort-

able again. The last bowel movement had occurred ten days before admission. Occasionally she had noticed blood in the stool. Urine, normal. Wassermann, negative.

Examination.—She was poorly nourished, of anemic appearance, and complaining of abdominal pain. The general physical condition was essentially negative excepting for the abdominal and anorectal findings.

The abdomen was distended, especially below the umbilicus. There was tympany throughout. No fluid wave nor shifting dullness were found. There was moderate tenderness in the left flank with abdominal spasm and sense of mass.

Anorectal examination revealed a marked peri-anal elephantiasis. About two inches from the anal opening there was a constriction too small to admit the finger. Proctoscopy showed a cylindrical stricture of the terminal rectum. A piece of this removed for section showed partially necrotic, infected granulation tissue with no special features.

A roentgenogram following a barium enema shows a low intestinal obstruction, demonstrated by a thready filling of the rectum and sigmoid, without ability to expel the enema. This could be produced by an extrinsic lesion. It is, however, suggested that this is probably due to infiltration in the wall of the gut. There is grave danger of the retained barium obstructing the canalized lumen and of producing an intestinal obstruction.

A Frei test was not done at this time due to difficulty in obtaining the antigen.

Preoperative Diagnosis.—Cylindrical rectal stricture and peri-anal elephantiasis caused by lymphogranuloma inguinale.

Operation.—August 21, under spinal anesthesia, 150 mg. of procaine hydrochloride being used, a loop colostomy of the transverse colon was done. We were unable to use a more distal portion of the colon because the entire rectum, sigmoid and descending colon were stenosed, with infiltration of all the coats.

Postoperative Course.—The colostomy was opened the day following operation, and began to function well on the third postoperative day. She was discharged on the twenty-fourth postoperative day with instructions to return to the hospital for attention to the peri-anal elephantiasis. In the meantime she was observed in the dispensary. A Frei test done September 25 was positive.

She was readmitted September 30, her general condition much improved and the colostomy functioning well. The peri-anal elephantiasis, however, was causing her considerable discomfort.

Operation.—The enormous peri-anal skin protuberances were removed with scissors on October 1, under spinal anesthesia. Section of the excised tissue showed a granulomatous process in thickened skin. Numerous foreign body giant cells were present.

Postoperative Course.—Her recovery was uneventful, and she was discharged on the sixth postoperative day. She is quite comfortable and does not complain of her colostomy.

CASE III.—Mrs. A. W., aged 46, Negress, a housewife, was admitted to the Brooklyn Hospital, September 12, 1933, complaining of anorectal discharge, lumps in the peri-anal region, and constipation of 15 months' duration.

She had had a fistulectomy 21 years ago; operation for rectal stricture 18 years ago; was reoperated on for rectal stricture 16 years ago; and for 12 years before admission had been receiving rectal dilatations regularly. She stated that for 15 months before admission she had developed peri-anal sinuses and swellings which not only failed to heal but increased in number and size. Her constipation had been constant, requiring cathartics and enemata.

Examination.—The patient was well developed and fairly well nourished. The heart and lungs were normal. Blood pressure 115/70. There was nothing of note found on abdominal examination excepting a suprapubic midline incisional scar.

Anorectal examination showed an extensive peri-anal elephantiasis with numerous sinuses discharging thin milky pus having a very foul odor. There were several large condylomatous bodies in each anal quadrant. About 5 cm. up from the anus, the rectum presented a dome-like stricture without a palpable orifice. On proctoscopy with an infant proctoscope, a cylindrical stricture which bled easily was found. The bowel beyond the stricture was normal in appearance.

The urine and blood chemistry were normal. The blood count showed a marked secondary anemia. The Wassermann was negative. A radiogram of the chest was negative, and one following a barium enema showed pathology of the rectum and distal portion of the sigmoid with a markedly redundant, mobile sigmoid. Frei tests with controls were positive.

Operation.—September 18, under spinal anesthesia, 150 mg. of procaine hydrochloride being used, a colostomy of the sigmoid flexure was performed.

Postoperative Course.—She had a stormy time for the first 48 hours, the temperature rising to 104.5° F. During this time, however, the abdomen was soft and there was no distention present. On the third postoperative day, the colostomy was opened, but it did not begin to function well until September 25, after which time recovery was uneventful. On the nineteenth postoperative day it was decided to dilate the rectal stricture and excise the esthiomene.

Operation.—October 7, under spinal anesthesia, 50 mg. of procaine hydrochloride being used, a plastic operation was done on the peri-anal elephantiasis, all indurated tissues and sinuses and fistulae being excised. It was thought inadvisable to do more than dilate the stricture with the finger at this time. The excised tissue showed a chronically infected tract in fat with foreign body giant cell reaction.

Postoperative Course.—Recovery was uneventful, and the patient was discharged 13 days following the last surgical procedure. She has had periodic dilatations, with the thought in mind that perhaps the colostomy could be closed after sufficient dilatation had been obtained, but the result thus far has been discouraging. She has gained considerable weight, is free from discomfort, and is quite active.

COMMENT

(1) After a fairly extensive search of the literature, no report has been found with colonic involvement as extensive as in Case II.

(2) The chronicity of this disease is well demonstrated by these cases.

(3) They illustrate three forms that the anorectal phase may assume, *i.e.*, (a) rectal stricture with peri-anal fistula, (b) rectal stricture with peri-anal elephantiasis, and (c) rectal stricture with elephantiasis and complicated with peri-anal fistulae. S  n  que⁵ also mentions uncomplicated rectal stricture, and rectal stricture with general pelvic cellulitis.

(4) Although Negro women are supposed to be peculiarly susceptible to this disease, two of these cases occurred in white women.

(5) These three patients each received several courses of tartar emetic intravenously. No recognizable benefit has been noted attributable to its use.

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INFILTRATING CARCINOMA OF BLADDER*

TOTAL CYSTECTOMY WITH BILATERAL NEPHROSTOMY

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CASE REPORT.—M. A., male, aged 45 years, was admitted to Mount Sinai Hospital August 2, 1934, discharged November 4, 1934, with the following past history and present illness:

Typhoid at the age of 12 and a painless hematuria ten years before admission which disappeared spontaneously. Two months ago he noticed blood in his urine at the end of micturition associated with dysuria. Hematuria and dysuria increased, then clots appeared in the urine. There was marked nocturia. Pain in the right groin became progressively worse. Occasional right lumbar pain was felt for five or six weeks before admission and in the last four weeks of this period he lost 22 lbs.

Physical Examination.—Marked pallor and emaciation. The right kidney was tender and the lower pole palpable. Rectal examination revealed a large mass above a slightly enlarged prostate. On the left side, there was distinct infiltration above the prostate. The urine was bloody (grossly). Roentgenographic examination of the genito-urinary tract was negative for calculus. The patient's condition was very poor and he was rapidly losing ground. His hemoglobin was 55 per cent and his temperature varied from 99° to 102°. He was given a citrate transfusion of 500 cc. of blood.

Cystoscopy.—August 6, 1934, under caudal anesthesia revealed an extensive neoplasm involving a large part of the bladder. The full extent could not be determined but it appeared to extend all around the sphincter margin occupying the posterior and lateral walls and covering the entire trigonal region. The tumor was in part covered by mucopurulent exudate. A number of sections were removed for biopsy studies. The ureteral orifices could not be seen.

Pathology.—Infiltrating squamous cell carcinoma.

Cystogram showed an enlarged bladder distinctly irregular in contour, with a large filling defect occupying the greater part of it.

Intravenous Urography.—August 10, 1934, showed extremely poor function from the right kidney. The dye appeared first in the 45 minute film. The calyces appeared dilated but there was good excretion from the left kidney. The pelvis and calyces were well outlined. The bladder showed a large filling defect occupying its major part.

In view of the persistent right lumbar tenderness and temperature, evidences of definite infection of the right kidney, he was operated upon August 14, 1934, under gas-oxygen anesthesia, a right nephrostomy with drainage being done. The kidney was found enlarged. The pelvis was aspirated and purulent urine obtained. Puncture opening was dilated and a Malecot catheter was inserted in the pelvis. Iodoform gauze drain was inserted and the abdominal wall sutured in layers. Following the operation, the temperature soon dropped to normal and the patient's general condition improved to such an extent that a week later cystectomy was decided upon.

Operation.—August 21, 1934, under spinal anesthesia supplemented by gas-oxygen. Total cystectomy and implantation of the left ureter into the iliac region. A median suprapubic incision exposed a huge, solid bladder which was mobilized with difficulty.

* Presented before the Joint Meeting of the New York Surgical Society and the Philadelphia Academy of Surgery, February 13, 1935.

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The neoplasm (Fig. 1) was found to occupy almost the entire organ. The opening in the bladder was closed with two layers of suture. The left ureter was exposed and found to be moderately dilated. It was divided close to the bladder which was then pedicled on the prostate, which was cut across with the endotherm knife. The ureter was implanted in a small gridiron incision internal to the left anterior spine. The abdomen was closed in layers, with rubber dam and gauze drains down to the pelvis. The patient reacted fairly well from the operation and was given a transfusion of 500 cc. of citrated blood.

August 31, 1934, the left ureterostomy, which had been functioning well, stopped

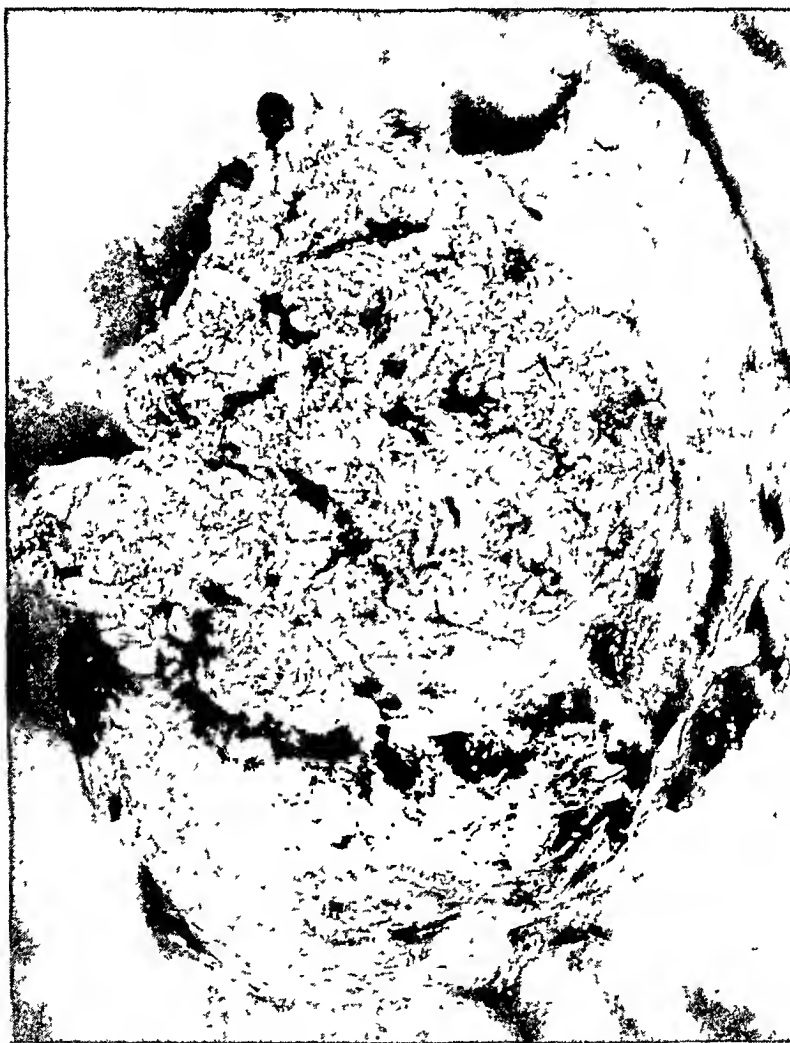


FIG. 1.—Showing practically complete replacement of cavity of bladder by tumor tissue.

draining. It was found that the ureter had sloughed away and the proximal end had retracted upwards. An attempt to insert catheters or tubes was unsuccessful. The patient was running a temperature of 102° to 103°. Left lumbar tenderness developed and it was decided to do a left nephrostomy.

Operation.—September 1, 1934, under gas-oxygen anesthesia. A left lumbar incision exposed a moderately enlarged kidney. The kidney was aspirated and cloudy urine obtained. The puncture hole was dilated and a Malecot catheter introduced. The abdominal wall was sutured in layers with drainage.

The patient's convalescence was protracted and stormy. Attacks of pyelonephritis developed. A large bed sore over the sacrum gave considerable trouble. However, he gradually improved and on November 4, 1934, three months after admission, he was discharged. He has gained considerable weight and both of his kidneys are secreting

well. The left kidney has a phthalein output of 60 per cent in two hours and the right 45 per cent. The bed sores have practically healed and in the three months since discharge he has gained 40 lbs., is able to attend to his affairs and suffers comparatively little inconvenience. He is at present receiving deep roentgen ray therapy.

Total cystectomy, although a very radical procedure, is indicated in this type of lesion for it is the only operation that will give the patient a chance for a cure. Although the published records show a high mortality, varying between 30 and 50 per cent, with careful pre- and postoperative care these figures should be appreciably lowered. In a series of 18 total cystectomies on the service of Doctor Beer, there was a mortality of 22 per cent. In carcinoma of the bladder it is preferable to transplant the ureters into the skin rather than to do a sigmoidal transplantation. Of 13 patients who survived operation, four are alive and well five years after operation (two for six, one for seven, and one for nine years). Of the remaining nine patients, eight have been operated on too recently to report upon and the other two are apparently cured two and one-half years in one case, and in another, one and one-half years after operation.

DR. LLOYD B. GREENE (Philadelphia) remarked that squamous cell carcinoma is one of the rarest and most malignant of the tumors occurring in the urinary bladder. Metastasis is slow and death generally results from the sequelae of lower ureteral obstruction. Coffee reported his experience in 11 cases some years ago. He carried out uretero-intestinal anastomosis with a primary mortality of 27 per cent. It was Doctor Greene's impression that Mr. Henry Wade has always favored bringing the ureters out on the anterior abdominal wall, a procedure easy to accomplish and possible at the time of cystectomy. In a recent article, Mr. Wade has advocated nephrostomy because of the almost impossible task of keeping these patients dry with ureterocutaneous fistulae. Nephrostomy may be practiced on both kidneys at one sitting and does not preclude uretero-intestinal anastomosis at a later date. In doing the nephrostomy, one should be certain to place the tube in the lowermost calix and endeavor to bring it out in such manner as to establish as straight a sinus tract as possible. The replacement of the tube is thereby made a simple matter and may be done by the patient or by some member of his family. There is practically no leakage and life may be very comfortable in spite of the complicated appearance of the apparatus. Marion, Boyd and others have reported patients alive and enjoying life 11 years after nephrostomy. Dr. B. A. Thomas had a patient in whom he had done a double nephrostomy who lived for 20 years.

MANAGEMENT OF VESICAL CALCULI

VISUALIZED LITHOLAPAXY

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OWING to the appreciation on the part of urologists that urinary stasis is the one constant predisposing factor in calculus formation, stones in the bladder can no longer be considered a distinct entity but must be classified as secondary to some preëxisting obstructive factor. In males the prostate

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is usually at fault. Frequent instances of repeated recurrence of vesical calculus have been noted in which a dietary regimen has been ineffective until the removal of the obstructing prostate, following which there were no more recurrences. Since the female bladder neck has no organ encircling and obstructing it like the prostate and in spite of the more sedentary life of women and the similarity of diet in both sexes, primary stones in these bladders are extremely uncommon. Very rarely a calculus having been passed down from the kidney or ureter remains and grows in the bladder on account of stricture or other obstruction in the urethra or vesical neck. Most of the stones found in the female bladder, however, are secondary deposits around foreign bodies introduced into it such as catheters, hair pins, safety pins, chewing gum, candles, tooth picks or sutures which have inadvertently been passed through the bladder mucosa during herniotomies or pelvic operations.

Civiale was apparently the first to suggest the employment of lithotripsy in this condition. Following his crude efforts and armamentarium, many others introduced modifications and improvements of his instrument but it was not until Bigelow of Boston finally standardized both the instrument and the procedure that litholapaxy or lithotripsy has become a popular and generally accepted method. Some urologists, however, still crush stones according to this 50 year old technic.

Prostatectomy at that time being practically unknown and the rôle played by prostatic hypertrophy in calculus formation apparently not appreciated, bladder stone was considered and treated as a disease entity. During that period, therefore, litholapaxy became a very popular and an extensively used procedure, being practiced by most of the surgeons of the time. The frequent recurrence following lithotripsy was attributed to faulty diet or metabolism, or to the technic rather than to the failure of removing the primary cause.

With the advent and development of suprapubic prostatectomy, lithotripsy waned rapidly to such a degree that it had practically become a lost art with many urologists of the younger school. Such an evolution was more or less justified since the stone could be so readily removed through the same incision during the suprapubic prostatectomy. The presence of a calculus in such cases was therefore only of passing interest and did not complicate the situation to any appreciable degree. Furthermore, following the removal of the obstructive pathology by prostatectomy, recurrence of the stone became more or less a remote possibility. Owing to this prevailing tendency towards operative intervention, many found themselves unable through lack of experience to cope with the rare stone that was still treated by lithotripsy. Due to this inexperience even in such rare instances the operation was naturally considered the safer procedure for the patient and certainly much easier for the surgeon than the difficult blind removal of lithotripsy. At present with transurethral removal of the prostate, the problem presented by the commonly associated bladder stones has again become impor-

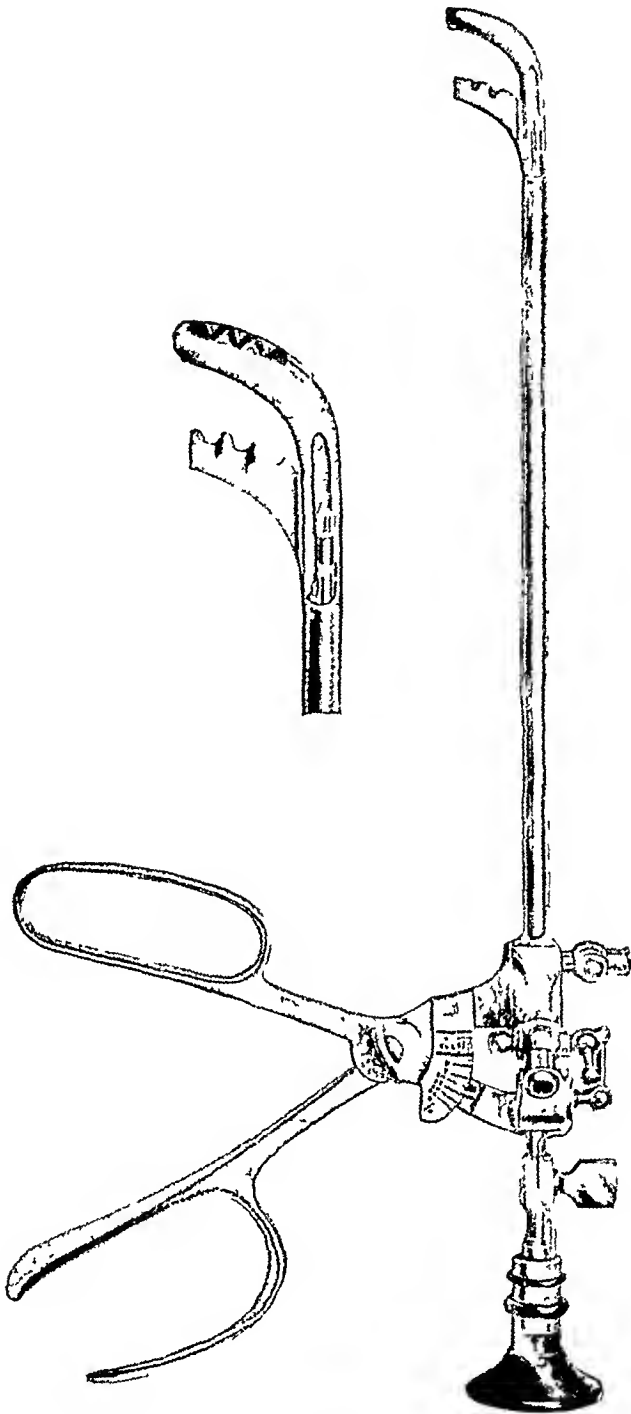
tant. Even though vesical calculus is not a disease entity it must first be treated by lithotripsy before vesical neck resection should be resorted to. Owing to the many defects inherent in the few frail cystoscopic lithotrites that had been introduced during the past 20 years, it is quite logical to expect continued dependence upon the more unwieldy sightless but safer lithotrites of the Bigelow type. Such a procedure entails the following steps: (1) cystoscopy for the diagnosis and localization of the stone, (2) introduction of the lithotrite with blind groping and crushing of the stone and each individual fragment, (3) introduction of the evacuator for the evacuation of the fragments, (4) reintroduction of the cystoscope to determine the presence of any fragments which may have been left over in the bladder, and (5) reinserting in the above sequence of all the previous steps for any of the fragments which frequently remain even after the most diligent search with the lithotrite. Aside from the time factor involved, and the great strain on both the operator and the patient, there is grave danger from the repeated trauma caused by the various instruments introduced into the urethra.

In 1928, a lithotriptoscope (Fig. 1) was presented which represented the basic principles of the original Bigelow lithotrite with all the strength of the original instrument. In it a telescope had been incorporated for grasping and crushing the stone under constant vision with evacuation of the fragments through the same instrument at the one sitting. The pistol handles which replace the old screw and pinion greatly facilitate and shorten the procedure. With a little experience lithotripsy can be done with fewer restrictions and with less effort than litholapaxy. Whereas formerly lithotripsy was contra-indicated for stones in the prostatic urethra or prostatic bed following incomplete prostatectomy, in so called hour-glass bladders, in contracted bladders, for multiple stones, and calculi associated with tumors of the bladder, none of these complicating conditions is now contra-indicated when done under direct vision. The only drawbacks to lithotripsy that remain are a coexisting diverticulum of the bladder which must of necessity be dealt operatively, or the presence of a very large prostate which should be removed suprapubically.

Recurring stones which occasionally form in the prostatic bed after incomplete enucleation of the prostate can very readily be grasped, lifted out into the bladder and crushed without danger to the existing lip. Most calculi impacted in the posterior urethra can also be pushed back into the bladder and crushed. In the presence of vesical tumors no one would attempt a blind type of litholapaxy for fear of grasping the tumor with the jaws of the lithotrite, causing uncontrollable bleeding, whereas with reasonable care lithotripsy can easily be done without danger. Multiple calculi can be handled as easily and rapidly as a single larger calculus.

Technic.—Due to very slight variations in the construction of the various lithotriptoscopes and telescopes manufactured since the first instrument was presented, minor difficulties had been encountered by a number of urologists, who wrongfully condemned the instrument because of their failure to prop-

Fig. 1.—Lithotriptoscope without obturator.



erly familiarize themselves with the minor adjustments necessary for the satisfactory performance of the procedure. With a little thought and care these adjustments are easily made and the technic mastered without difficulty.

Attempts have been made to grasp the calculus by bearing down on the floor of the bladder with the jaws of the lithotriptoscope pointing upwards as in the blind method. Such a maneuver, however, is unnecessary and awkward. Observing reasonable care there is no danger of grasping the mucosa of the bladder between the jaws directed downward since the male blade is shorter than the female. With a little practice the handle may be depressed slightly, thereby elevating the jaws away from the vesical floor before one proceeds to crush the stone.

In the original description of the technic the importance of constantly keeping both jaws in the field of vision was emphasized. The telescope being built on the left side of the lithotrite with the jaws and handle pointing downwards, the objective lens and the button on the ocular end indicating its direction should be anchored at about 5:30 o'clock. Being foreoblique in type if the telescope is pushed too far forward the female blade is clearly visible but the male blade is lost sight of when the jaws are opened. Such a maladjustment prevents proper manipulation of the lithotrite. One should familiarize himself with the proper relative position of the telescope before introduction and when the instrument is ready for use the telescope should be adjusted in the desired position by the set screw which locks it in place. A small metal collar into which the telescope fits more accurately has been added which is so fitted as to keep the jaws constantly in the field of vision without further adjustment.

In the presence of a cloudy medium much time can be saved by rapidly flushing the bladder through the irrigating channel with the telescope removed. The same holds true when the fragments and pulverized débris are being evacuated. The evacuator, either a Chismore or Young type, can be applied directly to the large outflow pet cock. During the evacuation of the fragments, the instrument with the jaws directed upwards should be depressed downwards onto the vesical floor and moved from side to side to empty the bladder of all the fragments. Since much of the débris will be lost in the form of powder during the irrigation, one must not expect as much sediment as with the older procedure of litholapaxy. The withdrawal of the lithotriptoscope and the introduction of a metal catheter for complete evacuation of the fragments as practiced by a few is unnecessary since the fragments are very small and can readily be evacuated through the large channel of the instrument. Unnecessary trauma to the urethra by change of instruments should be avoided as much as possible. To avoid clogging of the jaws with the cement-like débris of some stones the handles should be flicked back and forth rapidly from time to time. This dislodges the débris and prevents locking of the jaws and injury to the urethra during the withdrawal of the instrument. Trendelenburg posture is advisable to keep the

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stone and fragments as far away from the overhanging vesical neck as possible. A light low spinal or sacral anesthesia is recommended.

During the six years that this lithotriptoscope has been employed only one stone was found that was too hard to crush. This was quite large and being perfectly round and smooth it was impossible to dig the jaws into it and nibble it to pieces. It was removed by suprapubic cystotomy. No instance has occurred of breaking of the jaws in the bladder as one cannot grasp on the pistol handles powerfully enough to transmit that degree of tension necessary to cause this to happen. Very large, perfectly round calculi unless of an irregular contour are naturally not amenable to this type of procedure although stones the size of a small hen's egg can with patience be jockeyed into the jaws and may be gradually morcellated. Hematuria during this operation is rather rare. The insertion of an indwelling urethral catheter for several days is advisable to avoid urinary retention from possible edema of the bladder neck.

CONCLUSIONS

With the present day necessity for conservatism in prostatic surgery, as expressed by transurethral resection, proper management of the frequently associated vesical calculi assumes an important rôle. With the use of the present instrument the scope and indications for litholapaxy had been increased and simplified to a considerable degree. Although the technic had been outlined in several previous papers,^{1, 2, 3, 4} owing to slight variations in the lithotriptoscopes and telescopes certain defects have been corrected. Explanation has been offered of several of the more common difficulties encountered. With the proper performance of lithotriptoscopy many unnecessary cystotomies with the accompanying mortality, morbidity, prolonged hospitalization and convalescence can be avoided.

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CARCINOMA OF THE JEJUNUM *

REPORT OF THREE CASES

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SINCE the opening of The Roosevelt Hospital, 64 years ago, three specimens of carcinoma of the jejunum, are the only ones entered in the laboratory files. Nothnagel reports nine instances of carcinoma of the jejunum in 3,585 carcinoma deaths, and Johnson in a series of 41,883 autopsies in the Vienna General Hospital did not find a single case of carcinoma of the

* Presented before the New York Surgical Society, January 23, 1935.

jejunum, although there were in the same series 343 cases of carcinoma in other parts of the intestine. Up to 1934 there had been less than 200 cases reported in the literature. Those occurring close to Trietz's ligament (Case II) are very rare. The preoperative diagnosis is seldom made, the abdomen usually being opened for suspected gallbladder, or other biliary tract disease, peptic ulcer or chronic appendicitis with the symptoms referred to the epigastrium.

The symptoms and signs in the beginning are vague; as the disease advances, they depend upon the amount of stenosis present. Even in the later stages the symptoms are difficult to classify. The nonstenotic growths give very indefinite symptoms, unless (Case II) they have attached themselves to other abdominal viscera. Colicky pains in the epigastrium associated with nausea and vomiting of a large quantity of fluid containing bile, pancreatic juice and other duodenal content, should cause one to suspect cancer of the jejunum. Some French writers lay great stress on the extremely profuse vomiting of green fluid. A massive hemorrhage seldom occurs, yet by careful examination not infrequently occult blood may be found in the stools. Usually there is a secondary anemia of low grade. The diagnosis is seldom made before operation or postmortem examination.

The roentgen film has been of little aid up to the present time. With the tumor high in the jejunum, even slightly obstructive, the barium meal and fluoroscopy usually show a laking of barium remaining for a short time in the upper part of the small intestine shortly after it has passed through the duodenum. In indeterminate intestinal hemorrhage as in instances of bleeding Meckel's diverticula, the diagnosis of cancer of the jejunum, or, in fact, any part of the small intestine, should be corroborated or eliminated by immediate exploratory celiotomy.

Treatment is naturally a very prompt removal of the growth with excision of an abundant portion of the mesentery with anastomosis either end-to-end or side-to-side. It has been suggested that if the growth is close to Trietz's ligament, a preliminary gastro-enterostomy is advisable; however, it seems to me that if the tumor is not a stenotic one preliminary gastro-enterostomy is hardly necessary. In those having marked obstruction with dilatation of the upper jejunum, duodenum and stomach, Wangensteen's continuous suction is indicated postoperatively for a few days. Naturally in the debilitated patient with loss of weight, transfusion before and after operation will be of benefit.

CASE REPORT

CASE I.—H. A., a white American male, aged 50, a baker by occupation, was admitted to The Nassau Hospital on October 9, 1933, with a complaint of pain in the left groin of eight weeks duration, with vomiting for two weeks. I am able to present this specimen due to the courtesy of Dr. Benjamin Seaman of The Nassau Hospital, Mineola, Long Island, N. Y., who operated upon the patient, and also to that of Dr. Sophian, pathologist at The Roosevelt Hospital.

Present Illness.—While at work eight weeks before admission, the patient expe-

rienced pain in the left loin, which was followed by four succeeding, quite severe, attacks. There was no hematuria or burning. For two weeks vomiting has occurred after eating anything more than a few mouthfuls. The vomitus was bile stained and mucoid in character. There was increasing constipation. The patient lost ten pounds in this eight weeks period.

An important point of the physical examination was that in viewing the abdomen, particularly the epigastrium, peristalsis could be seen running from left to right. The umbilicus showed rhythmic retraction and below the umbilicus there was a wave of visible peristalsis from right to left. As the wave passed, a large loop of distended bowel pressed forward. A barium meal showed a dilated stomach and a duodenum distended with a gas bubble and fluid level.

Diagnosis.—Obstruction in the upper jejunum.

Operation.—On October 10, 1933, Doctor Seaman, disclosed a hard, annular neoplasm 20 inches from the origin of the jejunum, with marked dilatation above the growth, and collapsed bowel below. A portion of the jejunum 18 inches long was resected. Side-to-side anastomosis was done. Hard lymph nodes were noted in the mesentery and removed. The patient died 18 days later.

Autopsy revealed perforation of the suture line of the closed end of the upper loop. Peritonitis.

Pathologic Diagnosis.—Adenocarcinoma of the jejunum, Grade II, annular obstructive with metastases to the mesenteric lymph nodes. General peritonitis.

CASE II.—F. E. S., a male, night watchman, 65 years of age (Roosevelt Hospital history No. 341008). Admitted March 10, 1934, with the chief complaint of loss of vitality, abdominal pains and excessive flatulence during the last 18 months.

Present Illness.—Eighteen months before admission the patient fell, striking his left anterior chest wall. Prior to that he had felt perfectly well, subsequently his health began to fail. Distress in the epigastrium began at this time. It was indefinite at first, but later rather severe, coming on immediately after the intake of food, no radiation, although on some occasions it did not occur until 30 or 40 minutes later. The only way he could find relief was to lie face downward with his thighs flexed and his fists pressed against his epigastrium. After lying in this position for half an hour or so he was usually relieved of his pain and able to get up and go about his duties.

There was excessive flatulence with eructation of gas; he could hear the "rumbling of gas" in his abdomen. His constipation increased so that large quantities of cathartics were required to effect a movement. For some reason, when constipated, his epigastric pain was less, and recurred with renewed severity after evacuation. He gradually lost 16 pounds in weight and strength and at the time of entering the hospital was living on nothing but soups. For six months his pain had been almost constant across the lower abdomen, more marked in the right lower quadrant, and not related to meals or defecation. On one occasion, nine months before admission, he noticed bright red blood in his movements, but had not seen any tarry or clay colored stools. No nausea or vomiting. For six months there had been some increased frequency but no dysuria or hematuria.

Physical Examination showed the abdomen slightly distended. Borborignmi over the entire abdomen. There was a slight involuntary spasm over the right upper quadrant and resistance midway between the umbilicus and the symphysis. Just to the right of the midline there was a non-tender mass, 5 x 7 cm. in diameter, firm in consistency, irregular in outline and slightly movable. The liver and spleen were not felt. Rectal examination revealed a symmetrically enlarged prostate five times normal size.

Laboratory Findings.—Urine essentially negative. Hemoglobin, 82 per cent; R.B.C., 5,000,000; W.B.C., 12,000; polymorphonuclears, 78 per cent. Blood chemistry: urea nitrogen 12.3; sugar 138. Blood Wassermann, negative.

Roentgenographic studies of gastro-intestinal tract, negative.

Operation.—March 16, 1934. End-to-end suture; jejunostomy by Dr. Henry W. Cave.

Pathologic Report.—Adenocarcinoma of the jejunum, Grade III, with metastasis to the adjacent lymph nodes.

Result.—The patient made a satisfactory recovery. The jejunostomy opening closed on the twenty-third day after operation. Six months later, September, 1934, his family reported his death apparently from pneumonia. This, in my opinion, was terminal pneumonia, the real cause of his death the result of metastases.

CASE III.—J. R., a male, aged 76 years (Roosevelt Hospital No. B). Admitted April 28, 1934, complaining of jaundice, pain in the stomach, indigestion and loss of weight for a period of 14 months. An exploratory celiotomy was done, what was designated as carcinoma of the common bile duct was found and a cholecystoduodenostomy was performed.

Second Admission.—November 8, 1934, the patient returned to the hospital, having had pain during the interim, and complaining also of having had sour stomach and eructations for six months, with vomiting after each meal for the past two or three months. The vomitus was very watery and contained practically no solid matter. He had had no tarry stools and no jaundice, but had lost 15 pounds in weight.

Physical Examination revealed an extremely emaciated, elderly white man. There were numerous sonorous râles throughout both lungs. The radial arteries were extremely sclerotic. Abdominal examination revealed a large ventral hernia protruding through the old operative scar chiefly in the right upper quadrant.

Laboratory Findings.—R.B.C., 2,900,000; Hemoglobin, 50 per cent; Wassermann, negative; examination of feces for blood, negative.

Radiographic Examination.—A gastro-intestinal series showed marked dilatation of the stomach, with 90 per cent retention after six hours. There was almost total obstruction of the stomach by a lesion around the pylorus.

Preoperative Diagnosis.—A diagnosis of obstruction was made with cause unknown; ventral hernia; general arteriosclerosis; chronic bronchitis; secondary anemia.

Course.—The patient was rehabilitated by supportive measures and gained eight pounds in one month. December 7, 1934, under local anesthesia, exploratory celiotomy was done by Doctor Russell. On examining the small intestine a tumor of the jejunum was found just distal to the ligament of Trietz, lying within the lumen of the bowel. The mass was excised and the wound formed by removal of the tumor used to perform a posterior gastro-enterostomy. The following morning he became comatose and partially cyanotic. On the fourth day postoperative he died from what was thought to be cardiac failure.

Pathologic Report.—Macroscopic examination showed a cauliflower-like tumor measuring 6 x 5 x 3 cm. It had a short stalk 3 cm. in diameter. Microscopic examination showed regular gland spaces lined with dark hyperchromatic, irregular shaped cells invading the basement membrane. There were some large cystic areas containing mucus and glandlike spaces in the submucosal layer. Mitotic figures were present. Single cells could be seen in the muscular layer.

Diagnosis.—Papillary adenocarcinoma, Grade I.

DISCUSSION.—DR. WM. BARCLAY PARSONS, JR., found that in the past 20 years there had been six cases of small intestinal carcinoma, at the Presbyterian Hospital excluding carcinoma of the terminal ileum at or near the ileocecal valve. Of these, three were in the midileum and three in the jejunum proper.

Of the cases in the ileum, one was found by chance. The patient had been on the medical side with lobar pneumonia and pneumococcus endocarditis from which he succumbed. At postmortem examination, a small carcinoma

was found in the midileum which had never given any symptoms. The other two cases had some obstruction, one having in addition a very large retroperitoneal tumor, which was explored and found to be carcinoma. He died shortly after the operation and on postmortem examination the tumor of origin was found to be a carcinoma of the ileum. The third case was resected and was seen recently, 42 months following operation, and was apparently in good health.

Of the cases in the jejunum, one patient entered in very bad condition following prolonged chronic obstruction. He died postoperative and it was found he had a carcinoma of the jejunum. The second patient came in with acute obstruction due to a recurrent carcinoma of the colon at a previously made enterocolostomy; at postmortem a jejunal carcinoma was found arising in a polyp. Again, the jejunal lesion was an accidental finding. The third case had a resection of a carcinoma of the jejunum and two years later a carcinoma of the ovary weighing 15 pounds was removed which was considered at first to be of a different type. Seven months later the patient came in for general care with generalized carcinomatosis. Reexamination of the various specimens led the pathologist to feel that all of the tumors were of the same type, originating in the jejunum. We have had only these three autopsy cases of carcinoma of the jejunum out of 3,744 autopsies since 1917.

DR. C. J. MACGUIRE, JR., showed a case a few years ago of annular carcinoma of the jejunum about 14 inches below the ligament of Treitz. A complete exploratory operation demonstrated no metastases, but on speaking to the pathologist at the time he was told that these jejunal carcinomata were very malignant and that the prognosis was bad, in spite of failure to find metastases at the time of operation. A wide resection with end-to-end anastomosis was done. This patient died within eight months after presentation to this Society, with widespread abdominal carcinomatosis and without autopsy.

DR. EDWARD W. PETERSON had a case of carcinoma of the jejunum some years ago in a colored man, 46 years of age. At operation, an annular, scirrhus growth, 18 inches below the ligament of Treitz, was found. There were extensive metastases present, and no attempt was made to do a radical operation. A lateral anastomosis, side-tracking the growth, was made to relieve the intestinal obstruction. The patient died a few months later.

Recently Dr. R. Franklin Carter operated upon a case of carcinoma of the jejunum, occurring about eight inches from the ligament of Treitz. It was of the annular type. The patient is still living.

DOCTOR CAVE: The literature impresses one with the high degree of malignancy in the reported cases. Another feature is the high operative mortality ranging from 16 up to 32 per cent. In view of this he believed some type of extirpation operation might be advisable in carcinoma of the small bowel, similar to that employed in handling carcinoma of the large intestine; enterostomy above the tumor in many of these cases where there is obstruction is advisable. Most of the fatalities occur as a result of peritonitis at the site of anastomosis. Most writers on the subject have casually considered cancer of the small bowel usually amenable to primary resection, but he believed that where there is an obstruction we have the same condition to consider as in obstruction of the large bowel.

INJURIES OF THE SHOULDER GIRDLE

WILLIAM LISLE BELL, M.D.

OAKLAND, CALIFORNIA

IN ALL traumatic repair two major themes confront the surgeon: First—The restoration as nearly as possible of the normal anatomic structure and second the avoidance of injurious pressure to vital but innocent structures during this process of restoration. All methods, whether open or closed, metallic or otherwise, fixed or flexible, stationary, portable or ambulatory, must conform partly at least to these two desiderata. Minimizing of pressures and shock must include not only tissues adjacent to the injury but also those at some distance.

The splinting devices for the injuries considered are many. Velpeau and Desault gave us the fundamentals of treatment almost a century before Mathysen made plaster of Paris available as a true splinting product in 1852. The theorems propounded by these two workers have become well known. So far as we may learn Velpeau and Desault had nothing suitable, with which to construct rigid and dependable bases for secondary structures as we employ them today.

DISPLACEMENTS OF THE ACROMIOCLAVICULAR ARTICULATION

In analyzing three sets of records I find one of 1,900 fractures with two acromioclavicular displacements, another of 3,500 with 11, and a third series of 200 with 20. We are concerned with the treatment and results of the three injuries considered in this article which are so interlocked in their methods of treatment and so similar in basic construction that they may well be grouped together.

It was evident that a central, firm, practically immovable base must be constructed from which appliances could reach out and around the innocent structures and apply directing force where needed, and in such a way that each step could be controlled independently or in any combination with other procedures.

Method.—A chest girdle of plaster of Paris eight to ten thicknesses, four to six inches wide, incorporating a bent metal wicket over the injured shoulder is applied snugly to the chest over several wide turns of sheet wadding. Two shoulder straps of firm but light canvas (six ounce) well padded on top of each shoulder which pass beneath the chest girdle and sheet wadding are turned backward front and rear over the lower edge of plaster of Paris girdle and tightened so as to lift this girdle just snugly but not too closely against each axilla. The arm and forearm lightly encased, with the elbow at a right angle, are now elevated by strong cords passing from the wickets emergence from plaster in the rear, down and around the midelbow, up in front and anchored to the wicket where it emerges from the plaster jacket in front of the axilla. This elevating cord or cords should not be forward on the forearm and may be movably retained by a loose bracket of

SHOULDER GIRDLE INJURIES

small wire passing over it where it crosses the elbow. A handkerchief or other firm bandage may be used in lieu of the cord. This strong elevating cord may be doubled and incorporated in the plaster of Paris chest girdle under the olecranon. The loose ends must be sufficiently long to tie easily and firmly around the wicket at the top edge of plaster of Paris and forearm at a right angle runs far enough out to support the ulnar side of the hand but is cut very thin (one or two plaster bandages) balanced and thicker of course at the elbow. Light sheet wadding underneath this arm case and much sheet wadding (20 thicknesses) between plaster case and olecranon. If more limitation of motion is desired in the arm and forearm a light circular bandage may surround arm and chest.

The number of these cases that come to us for operation and the vast array of operations suggested for relief bear witness to the inadequacy of the primary correction. It is frequently said that such a shoulder widely separated and torn cannot return to function without radical surgical aid. The injury should be splinted within three or four days, better three or four hours.

The basic technic is identical for acromioclavicular dislocations, tears or for fractured clavicles. The detail of the two procedures differs somewhat. In both conditions we employ the rigid chest girdle, the suspenders, the wicket, the plaster encased arm and the arm lift. In acromioclavicular dislocations the suspender on the injured side may be wide and approach very near the acromion process where it crosses the clavicle. Its lower extremity too may be slightly farther away from the anterior midbody line where it rests in a shallow notch in the lower edge of the plaster girdle. This gives it more nearly a vertical position with the patient standing. With the fractured clavicle this shoulder strap should be narrower and rest with its thick pad over the inner clavicular fragment. The lower extremity of this suspender where it turns around the lower edge of chest girdle should be one to two inches nearer the median line. This inward angulation at the lower end prevents the strap from creeping outward from the base of the neck and losing its downward pull on the inner fragment. The large firm pad which I always use between the wicket and anterior surface of the shoulder for "shoulder back" in fractured clavicles is sometimes dispensed with in acromioclavicular dislocations. The wicket is advisable in both injuries. It stiffens the plaster girdle and forms two rigid bars for attachment of the arm lift cords or bandage. A section of wooden tongue depressor fastened across shoulder straps with half inch adhesive tape on top of each shoulder prevents the shoulder strap from wrinkling or roping. If one is meticulous the chest girdle may be trimmed well below the axillary folds on the injured side, leaving a fully exposed axillary space.

The application of this mechanism is rapid. Its purpose plain. Any amount of downward pressure may be imposed upon the displaced clavicle

up to the point of tolerance. The arm is lifted at the same time which brings the acromion into place. Neither lifting cords nor shoulder straps slip or creep. They are firmly anchored to the rigid dependable chest girdle. The pull of the arm lifting cords around the deeply padded but lightly plaster encased elbow, is downward on the plaster girdle at B. This downward pull lowers the chest girdle PG completely away from the axilla and at the same moment by its cantilever action depresses the clavicle. The more vigorously we lift the arm the more firmly we depress the clavicle—all the while open-

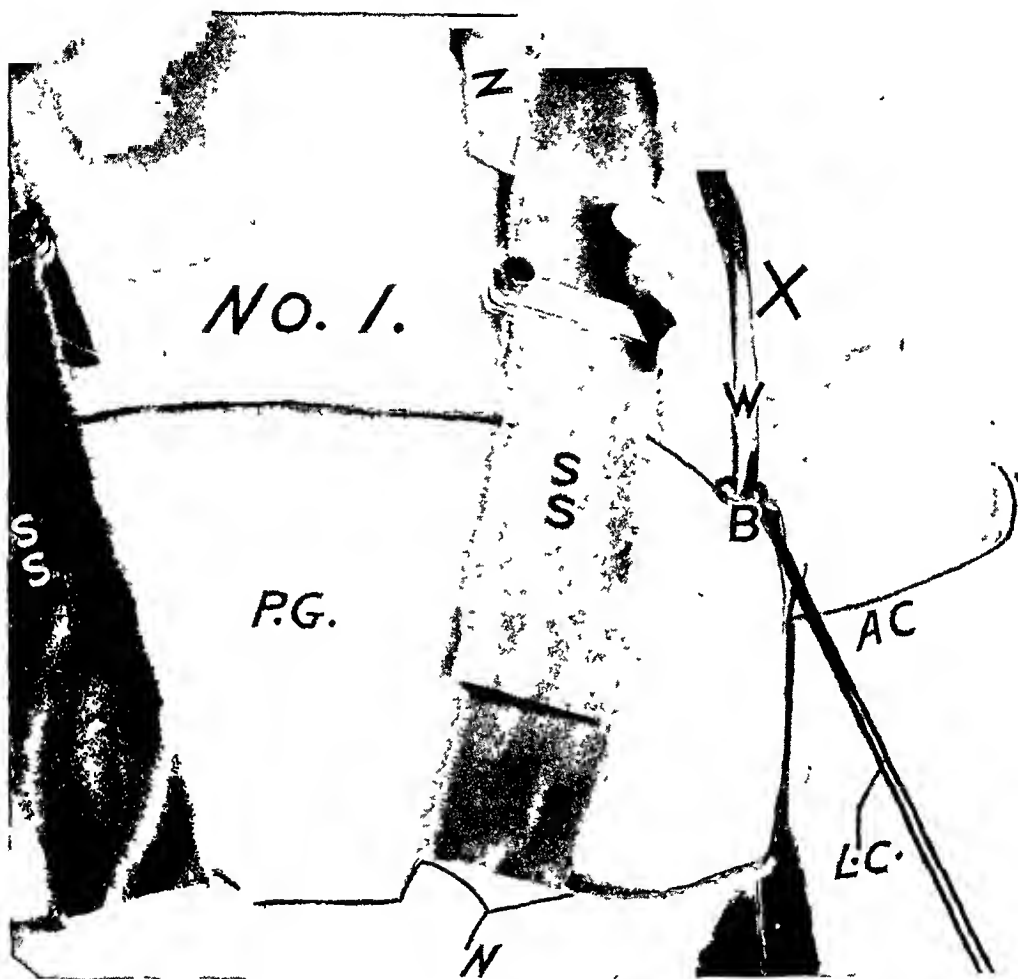


FIG 1.—Displaced acromioclavicular articulation and fractured clavicle SS—Firm shoulder straps PG—Plaster chest girdle held firmly by straps SS Z—Pads under straps. W—Wicket front and rear of shoulder X—Pad against wicket for shoulder back LC—Lifting cord or bandage N—Notches in plaster for preventing side slipping of shoulder straps B—Wicket buried in plaster to which is tied arm elevating cord LC

ing a wider space between top edge of chest girdle and axilla. This pressure must be moderate. Too much tension on the arm lifting slings will cause the patient discomfort at Z under the shoulder strap. If the mere weight of the arm and forearm transferred around the axilla to Z is uncomfortable, this weight may be slightly lessened by supporting the forearm from the wrist to the shoulder strap of the uninjured side. This procedure will rarely be found necessary (Fig. 1).

SHOULDER GIRDLE INJURIES

FRACTURED CLAVICLES

Figure 1 completely portrays the technic in these injuries. The inner clavicular fragment is held downward, the outer fragment and acromion elevated and the shoulder softly and comfortably but dependably pushed backward by the firmly rolled sheet wadding pad X between wicket and shoulder. Two fractured clavicles in the same patient are just as expeditiously treated. The patient may rest fairly comfortably in bed. No adhesive plaster touches the skin. The chest plaster girdle is wide and firm in every direction and

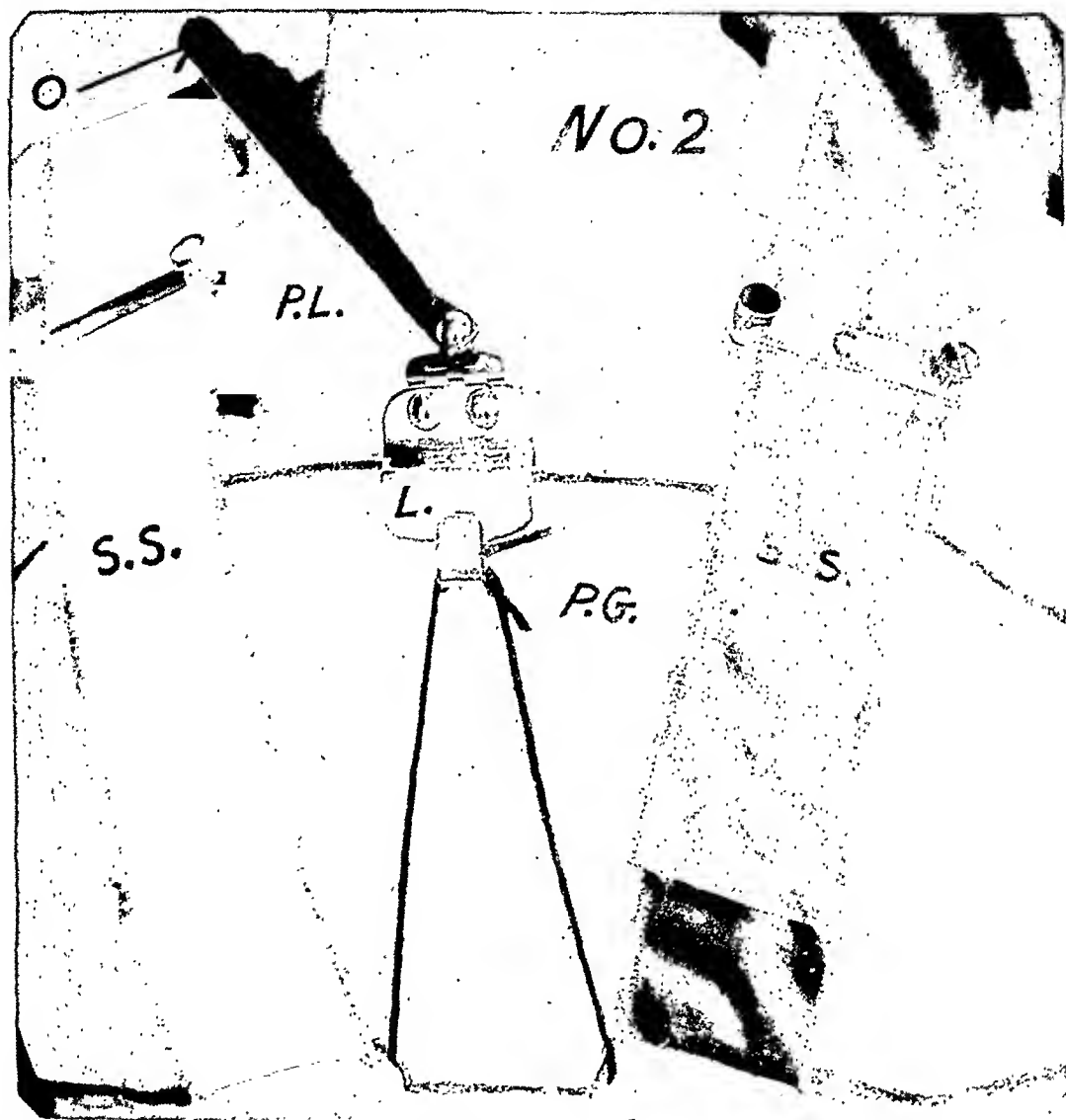


FIG. 2.—Displaced clavicle at sternum. P.G.—Rigid fitting plaster of paris chest girdle. S.S.—Padded shoulder straps. L.—Lever anchored to P.G. as rigid fulcrum. P.L.—Compression pad under lever and over inner end of clavicle. O.—Hole in rear end of lever for depressing cord to plaster case on back. No wicket on arm lift in this treatment.

does not cut in or pull out of shape as do circular chest straps. The bent shoulder wicket made of one-quarter inch round duralumin rod or steel rests closely against the shoulder in front when the shoulder is well back, but is four inches above on top and four inches to the rear of the posterior aspect of the shoulder. This allows sufficient space for movement of the shoulder well upward and backward. It is astonishing how much elevation and posterior position we sometimes need to obtain even a fair correction.

The narrower shoulder strap with its slightly different angle was discussed under acromioclavicular injuries. Good sized fenestra up to two inches in diameter may be cut (always circular) in the chest girdle at appropriate points.

FORWARD DISPLACEMENT OF THE CLAVICLE AT THE STERNUM STERNOCLAVICULAR DISPLACEMENT

Forward or forward and upward displacement seems to be the rule at this articulation. I feel that this condition is frequently overlooked; particularly where the displacement is not great or the patient has other injuries of greater moment.

A flexible lever is constructed, attached to the midline in front, a bandage roll placed over the inner end of displaced clavicle and pressure downward and backward completed by depressing the posterior perforated end of lever by means of a cord from rear lever end down to and around posterior portion of chest girdle (Fig. 2). I like to immobilize this displacement 10 to 12 weeks. And the utmost care should be enjoined to prevent slipping of structures during this time. It is not unusual to find a displacement or tearing of ligaments at this point in fractures of the clavicle. This leaves a very movable inner fragment and one difficult to control. In such cases this additional lever is readily placed in position and helps remarkably in controlling this inner fragment. The space for its placing is wide open.

In fractured ribs when accompanying other injuries the chest girdle also has its value. In both sternoclavicular dislocations and fractured ribs, arm lifts are of course dispensed with. The girdle is wider in most cases of fractured ribs and quite tight. If it loosens it may be sectioned in front and its lumen narrowed with adhesive tape. This gives us a continuous follow up pressure as long as needed. As opposed to many I believe in complete encasement of the chest in fractured ribs. Limitation of pulmonary excursion gives rest to both the lungs and the patient. This jacket is light, comfortable, does not irritate the skin and with the two shoulder straps remains in place. Its removal is simple and does not entail any of the discomfort occasioned by adhesive tape.

In fractured clavicles the period of 10 to 20 days treatment induces no permanent fibrosis at the elbow or shoulder. In displacements of the acromioclavicular articulation which seem to demand not less than eight weeks and often more prolonged fixation, the plaster case may be bisected horizontally from around elbow to hand. This produces a removable under half of the forearm case. When the patient is supine this lower half may be removed, the elbow straightened and gently massaged. This light arm and forearm plaster of Paris case is merely to distribute pressure. A considerable space exists between its top and the chest girdle. They are not fused or connected at any time except movably through the elevating cords or bandage.

HORNER'S SYNDROME *

FOLLOWING CERVICAL SYMPATHETIC NERVE BLOCK TO THE UPPER
EXTREMITY

RUSSEL H. PATTERSON, M.D.

NEW YORK

CASE REPORT.—J. P. M., aged 22 years, an American male, was admitted to Cornell Clinic in September, 1931 (History No. 83505) and later, in January, 1932, to Bellevue Hospital.

Chief Complaint.—Pain and swelling of various joints of eight months' duration.

Present Illness.—Insidious onset eight months ago. Pain and swelling of fingers, wrists and knees, and pain and stiffness in the shoulders.

Physical Examination.—Fusiform fingers with slight limitation of motion of the wrists, shoulders and left knee. There is a tendency to cold, clammy hands.

Diagnosis.—As a result of serologic tests by Dr. W. Stainsby and physical examination in a diagnosis of rheumatoid arthritis, early and moderately active, was made.

February 11, 1932, the first and second left dorsal sympathetic ganglion areas† were injected with first 3 cc. of 2 per cent procain and 30 minutes later 4 cc. of absolute alcohol in each of the same areas. There was a maximum increase of 12° F. in surface temperature at the finger tips and in the characteristic manner as the elbow and axilla were approached the skin temperature gradually reached normal. A Horner's syndrome appeared on the left side.

February 13, 1932, the first and second left lumbar sympathetic ganglion areas were blocked in a similar manner with procain and alcohol and there was the same relative increase in temperature of the left lower extremity.

February 16, 1932, the right second and third dorsal sympathetic ganglion areas were blocked in a similar manner as those had been on the left side February 11. There was the same proportionate rise in surface temperature and a marked Horner's syndrome appeared. At this time it was noticed that there was a decrease in the temperature elevation of the left upper extremity and also the Horner's syndrome on the left side had practically disappeared.

February 18, 1932, the first and second right lumbar sympathetic ganglion areas were blocked in a similar manner as those on the left, with like results.

In March, 1932, it was noted that the right hand and both feet were warm and dry, the left hand was cold and clammy, evidently the left dorsal injection had not been effectual. Horner's syndrome was very marked on the right, but not present on the left.

January 6, 1933, or about 11 months after the sympathetic alcohol blocks, the patient was again examined. There was definite evidence of a moderate Horner's syndrome still present in the right eye, there being very slight ptosis of the right eyelid, incomplete reaction of the pupil to light, and dryness of the right side of the face. The arthritic symptoms were much less marked. The acute swelling and pain had almost disappeared.

COMMENT

(1) Horner's syndrome is relatively infrequent.

(2) The syndrome was produced by the introduction of alcohol about

* Presented before The New York Surgical Society, February 27, 1935.

† It should be pointed out that after our experience with 25 or more of these injections on human beings we found that a complete blockage of the sympathetics to the upper extremity was always obtained if the solution was injected about the first and second dorsal sympathetic ganglion areas. It is assumed that the solution extends up the sympathetic chain and includes the stellate ganglion and also extends downward to about the fourth dorsal ganglion.

the sympathetic ganglia in the lower part of the neck and the upper dorsal region. The alcohol certainly was not injected directly into the ganglia but probably diffused into the loose areolar tissue around the ganglia and formed dense scar tissue which cut off the nerve impulses. I know of only one case so treated and later autopsied. This was done by Dr. J. C. White of Boston who blocked the upper dorsal ganglia in a case of angina. Several months later, when the patient died, at autopsy only scar tissue could be found at the sites of the previous injections.

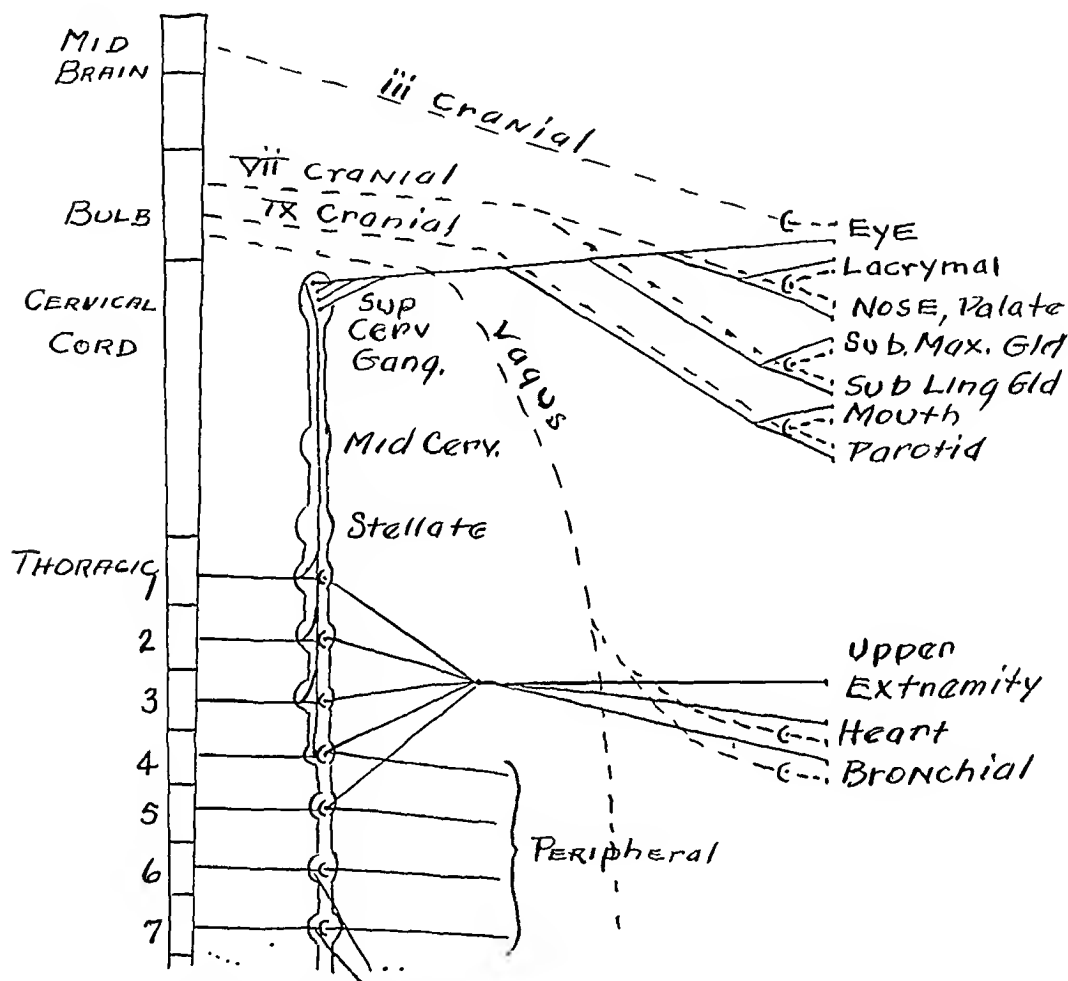


FIG. 1.—Shows diagram of upper thoracic and stellate sympathetic ganglia illustrating the fact that excision or blocking of these ganglia does three things: it interrupts the sympathetics to the upper extremity; it interrupts the entire cervical sympathetic, and it interrupts the afferent fibers from the heart and bronchi.

(3) This case illustrates a very important fact: that with present technic we are unable to interrupt completely the sympathetics to the upper extremity without interrupting the sympathetics to three other important parts of the body, namely, the cervical sympathetics, which supply the eye and when interrupted produce Horner's syndrome, and the afferent sympathetics from cardiac and pulmonary plexuses (Fig. 1). Before interrupting the sympathetics to the upper extremity we must decide whether or not the interruption will result in sufficient benefit to the extremity to outweigh the detri-

mental effects of the associated interruption of the sympathetics to the eye and chest organs.

(4) Another interesting point is whether or not the production of a Horner's syndrome really brings about a real enophthalmus or whether such is merely apparent due to the drooping of the eyelid. This point has not been definitely determined. The application of this idea has been tried many times. According to Parsons, the benefit in two cases of exophthalmic goiter seemed to be due to a paralysis of Müller's muscle, and there was no resultant decrease in the exophthalmus.

(5) Parsons stated further that he would hesitate to use the operation on both sides because of possible interference with night vision. Adson, however, reports that the condition, when bilateral, is rarely complained of unless unequal and also that there is no serious interference with vision in the dark.

(6) White states that when the operation of blocking is not carried above the first dorsal ganglion, only a slight Horner's syndrome appears; but if the inferior cervical ganglion is included a permanent Horner's syndrome follows. We have found this to be true in the cases we have done.

DISCUSSION.—DR. IRA COHEN said that the case presented by Doctor Patterson demonstrated that one cannot interrupt the sympathetic supply to the upper extremity without producing Horner's syndrome. In fact, that is one of the certain means of telling whether the alcohol injection has been properly placed. From the inferior cervical ganglion the sympathetic nerves go to the seventh and eighth cervical and sometimes the sixth and seventh thoracic nerves. From the middle ganglion they go to the fifth and sixth. If this ganglion is absent they often come off the trunk. Therefore, if one properly interrupts the sympathetic supply to the upper extremity one has to interfere with the sympathetic chain and a Horner's syndrome will result. Whether this syndrome is lasting, or not, depends entirely upon the completeness of the interference. It seems to grow less in some cases, even after removal of the upper thoracic and the stellate ganglia. It is rather unusual for an alcohol injection to give a complete Horner's syndrome lasting over a period of several years. Usually there will be found a recession and more or less improvement.

NOTE.—This case is one of a group of cases so treated by Dr. Wendell Stainsby and myself on the Cornell Division at Bellevue Hospital.

CARCINOMA OF PAPILLA OF VATER *

RESECTION OF DUODENUM AND HEAD OF PANCREAS

WILLIAM BARCLAY PARSONS, M.D., AND CLINTON R. MULLINS, M.D.

NEW YORK

CASE REPORT.—E. W., Unit History No. 422738, admitted to Presbyterian Hospital July 16, 1934, complaining of itching and jaundice of two months' duration. He was a boatman, 53 years old. Grandfather died of carcinoma of the stomach. Otherwise the family and personal history were irrelevant. Three months before admission, the patient had some bad colds and his appetite began to fail so that when first seen he weighed

* Presented before the Joint Meeting of the New York Surgical Society and the Philadelphia Academy of Surgery, February 13, 1935.

only 125 pounds, representing a loss of 20 pounds in this brief period. One month later, itching developed, followed shortly by jaundice. There was nausea but no vomiting and no pain. He was markedly constipated and the stools were clay colored, the urine dark.

Physical examination revealed a poorly nourished, intensely jaundiced man, with numerous small scratch marks over his trunk. The abdomen was slightly distended and what was judged to be a large, distended gallbladder could be felt in the right upper abdomen. The liver was enlarged and palpable two fingers below the costal margin. The laboratory findings were: Wassermann, negative; serum bilirubin, 10.7 mg. per cent; blood amylase, 5.8; R.B.C., 2,700,000; Hb., 77 per cent, and no bile obtainable by duodenal drainage.

The diagnosis was obstructive jaundice, due probably to carcinoma of the pancreas. At operation, July 18, the gallbladder was found to be markedly distended but neither



FIG. 1.—Showing prominent papilla of Vater.

it nor the common duet contained stones. A hard, small mass was felt in the head of the pancreas, near the papilla of Vater, on the deep surface. No metastases were seen in the liver. A cholecystogastrostomy was performed.

The patient recovered satisfactorily from the operation. His serum bilirubin fell, the jaundice cleared, and itching improved. However, considerable anemia was still present at the end of two weeks. Liver extract and repeated small transfusions were commenced.

In view of the fact that dogs tolerate complete severance of the duet connection with the duodenum and that patients with lesions in all probability obstructing the pancreatic flow have survived for considerable periods of time following cholecystogastrostomy, resection of the head of the pancreas was suggested by Doctor Mullins.

After a few days at home, the patient returned for a partial pancreatectomy. He was in fairly good condition, weighing 116 pounds and with a serum bilirubin of 2.5 mg. per cent.

CARCINOMA OF PAPILLA OF VATER

August 21, under pantocaine anesthesia, the abdomen was reopened through a slanting oblique transverse upper abdominal incision. The stomach and gallbladder were adherent to the under surface of the liver and it was impossible to view the cholecystogastrostomy. The duodenum was liberated from the superior angle down to the line of the superior mesenteric vessels, and turned inward with the head of the pancreas. The lesion was found to consist of a hard mass in the region of the papilla of Vater. The adjacent pancreas was somewhat thickened. A dilated common duct was found, but was torn in the first attempt to pass a ligature around it. The duct was opened, cut across, and the upper stump ligated with silk. Clamps were applied to the duodenum well above and below the papilla of Vater, and the duodenum cut across. A wedge-shaped section of pancreas was then excised, cutting being done in front of clamps, as in a thyroidec-tomy. Hemostasis was effected, the pancreatic duct being recognized and included in one of the ligatures. An end-to-end anastomosis of the duodenum was easily accom-

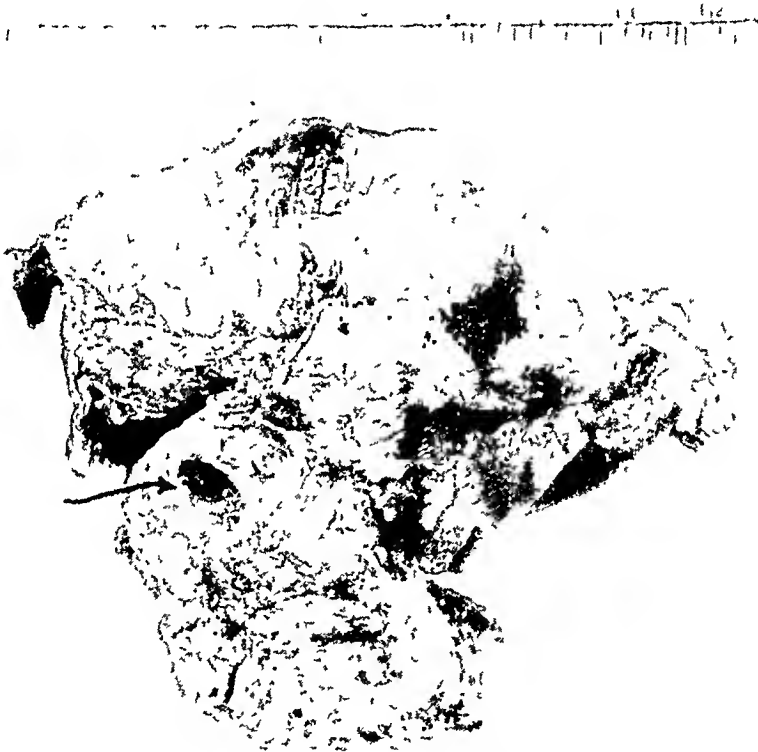


FIG. 2.—Rear view of specimen, showing enlarged common duct leading down to papilla.

plished because of the wide freeing of the duodenum and the partial removal of the pancreatic head. Mattress sutures of silk were used for the outer layer, and continuous catgut for the inner layer. The raw surface of the pancreas was closed with a large mattress suture. One Penrose drain was inserted lateral to the site of the anastomosis, the omentum being tucked around the anastomosis and over the surface of the pancreas. The operation took two and one-quarter hours. Except for a drop of blood pressure at the end of the first hour, controlled by a second injection of ephedrin and morphine, the condition was very satisfactory.

Persistent vomiting commenced on the first postoperative day, at first in small amounts. A nasal tube was inserted and the drainage by the second day amounted to 500 cc., in addition to 100 cc. of vomitus and considerable fluid obtained by lavage. For the next several days about two liters a day were vomited and then, on the seventh day, the vomitus and gastric lavage return exceeded three liters. The abdomen was distended and it was quite obvious that there was a high obstruction, either from constriction at the anastomosis, or, more probably, from traction against the superior mesenteric vessels.

August 29, the abdomen was again opened under pantocaine. The area of the

previous operation was not inspected. To attempt a posterior gastro-enterostomy might easily have disturbed valuable adhesions, so a long-loop anterior gastro-enterostomy, with an entero-enterostomy a comfortable distance below, was done. A transfusion was given at the close of the operation, notwithstanding the satisfactory condition of the patient.

A slow but excellent recovery was made. The blood amylase curve followed closely that found experimentally in ligation of the pancreatic duct, namely, a very high rise to 76 within the first 24 hours, followed by a gradual drop of values. There was considerable abdominal distension and some constipation, the stools tending to be bulky. Fluid obtained through a duodenal tube showed a rather powerful lipase and protease reaction, but no amylase. A good blood pressure was maintained and the patient was allowed out of bed on the twentieth postoperative day and home on the fifty-fourth, weighing 98 pounds.

Pathologic report, by Dr. A. P. Stout.—Gross—The specimen is a segment of the duodenum together with a portion of the head of the pancreas and the common duct.



FIG. 3.—Low power photomicrograph showing: (A) Mucous membrane of duodenum. (B) Tumor. (C) Where tumor impinges on duodenal mucous membrane. (D) Where tumor is beginning invasion of pancreas. (E) Blind end of common duct. (F) Extension of tumor along mucous membrane of common duct.

After fixation in pyradine formol, the duodenal segment measures 9 cm. in length along the antimesenteric border. The duodenum seems relatively normal except for some fresh hemorrhage due to operative trauma. The papilla of Vater is represented by a nipple-like projection 5 Mm. in diameter (Fig. 1), covered with mucosa. No lumen can be found. Beneath it can be felt a hard mass which unites it with a common duct. A piece of common duct about 6 Mm. long has been removed. Through the line of resection it is much dilated (Fig. 2), measuring 1.5 cm. in diameter, but this quickly narrows to nothing as there is no communication with the duodenum. The termination of the duct is therefore cup-shaped and is surrounded by the head of the pancreas, which is 4 cm. long, 5 cm. wide, and 4 cm. thick.

A section through the pancreas, common duct and papilla shows that the termination of the duct is separated from the papilla by a firm, ovoid, pale yellow tumor about 1.2 cm. in its greatest diameter and 8 Mm. wide. The duodenal mucosa is intact over it, although seemingly it has involved the muscular coat of the duodenum.

Fixation in pyradine formol. Section through papilla, duct, pancreas, and adjacent duodenal wall. Small piece of tumor for quick diagnosis. One segment of pancreas fixed in Zenker.

A reexamination of the gross specimen shows a cut section of the pancreatic duct which passes through the pancreas near the common duct and seemingly loses itself in the tumor mass.

Microscopic.—A section taken through the papilla, the tumor, the duodenal wall, the end of the common duct, and the adjacent pancreas shows that the tumor extends from the duodenal mucosa to the bulbous end of the common duct. Laterally it is sharply circumscribed by the pancreas and the duodenal wall. It is composed of well differentiated glandlike structures which are lined with epithelial cells varying from cuboidal to columnar, most of which maintain their nuclear polarity. There is marked tendency for the cells lining some of the neoplastic glands to form papillary projections into their dilated lumens. Secretion of mucin is observed in many of the tumor cells. Mitoses average one in every three or four high power fields. The tumor glands apparently replace the duodenal glands on the papilla itself. They have invaded the adjacent muscularis of the duodenum and the muscular remnants of the obliterated common duct, but they have not extended to any appreciable distance, and the pancreas appears free. The section does not show any evidence of the pancreatic duct. The bulbous end of the common duct is lined with a papillary epithelial tissue which more nearly resembles the tumor than it does the duct epithelium.

This is apparently a well differentiated, mucin secreting adenocarcinoma of the papilla of Vater, probably arising from the mucosa of the common duct. It has obliterated and replaced the common duct for its terminal 11 Mm. Apparently it has been generously removed on all sides except along the common duct itself. Since the tissue lining this more nearly resembles the neoplasm than it does the normal mucous membrane, one has to fear a reappearance along the divided common duct.

Diagnosis: Carcinoma of the papilla of Vater.

Follow Up.—At first, the patient's appetite was ravenous, but with a gain in weight, aggregating 40 pounds in the four months since discharge, this has become normal. The patient has been doing some work. There is one bowel movement a day, the stool being of normal brown color, neither oily nor frothy; stool examinations, against a weighed diet, show fat and protein absorption as follows:

Days Postop.	Cho.	Diet		Percentage Absorbed	
		P.	F.	Protein	Fat
18.....	100	60	40	84%	64%
28.....	200	70	40	56%	58%
40.....	200	70	40	76%	64%
90.....	300	120	110	83%	88%

This would seem to indicate that the lipase which has been found in the gastric and intestinal contents has been sufficient to maintain a good margin in his favor.

COMMENT

This case is presented as a successful six months' result of what we believe to be a new method of handling the problem of carcinoma at or around the papilla of Vater. A variety of procedures, involving reimplantation of the common duct or the stump of the pancreas have been tried with varying immediate and delayed success, as reported by Cohen and Colp, Walters, Muller and others. So far we have found no description of a procedure similar to the present one in the literature. Autopsy evidence indicates that growth from the original lesion is at first along the common duct

and into the neighboring pancreas, before distant dissemination occurs. In the early stages of the disease, complete eradication might be secured by free resection of the common duct below the cystic, of the duodenum including the papilla, and of the neighboring pancreas.

Because of its magnitude, the procedure must be done in two stages. The gallbladder should be anastomosed, not to the duodenum but to the stomach, to keep it as far as possible from the operative field at the second operation. In the case presented, one of the difficult steps was the isolation, ligation and section of the common duct at the second stage. This maneuver, therefore, should be carried out at the first operation, and the lower end marked by a ligature of black silk with the ends left long, to serve as a guide. Although anastomosis of the duodenum was extremely easy, this should not be done because of the great risk of obstruction. The duodenum withstands pressure or traction very poorly; and while an anastomosis may be competent, nevertheless there is very apt to be a drag set up against the superior mesenteric vessels. It is suggested that a gastro-enterostomy be done at the first stage.

At the second stage, done preferably after two or three weeks, there would be liberation of the duodenum and the head of the pancreas, with a liberal resection of the duodenum, and the removal of a wedge-shaped section of the pancreatic duct, plus the lower portion of the common duct. The possibility of employing this procedure must be considered in cases of jaundice from tumor, when the tumor is at or around the papilla and seems still to be localized.

The prognosis in the case shown would seem to depend on whether the section through the common duct was or was not above the limits of the tumor. From a physiologic standpoint, this patient's digestive apparatus is apparently functioning at a level of efficiency which would indicate that he is compensating adequately for the loss of his pancreatic ferments. There is, of course, no thought that his island tissue will degenerate.

DISCUSSION.—DR. GEORGE P. MULLER (Philadelphia) stated that although resembling in general plan several procedures described in the literature, that detailed by Doctor Parsons seemed to be much simpler and more satisfactory, having filled the requirements of a good technical procedure insofar as a period of six months indicates the permanency of the end-result. He described a similar case that he had treated ten years ago by a method then in vogue with Mayo and Stein. The duodenum was opened and the area of carcinoma thoroughly cauterized with the actual cautery, after which a rubber tube was inserted into the common duct and sewed in place to prevent stricture at the duodenal orifice. At the end of one year the patient was fine and the case was reported to the American Surgical Association as a one year cure. Subsequently, he again became jaundiced and a cholecystogastrostomy was performed. He remained well for several years, then within a brief period masses appeared in the upper abdomen and vomiting occurred. The patient was reoperated on but, owing to adhesions, the site of the original operation could not be uncovered. A gastro-enterostomy was done and he was well for awhile, but eventually died, four years and eight months after the original operation.

A second case was seen by Doctor Muller two years ago, a woman who

had had carcinoma of the breast five years previously. Because of jaundice, she was looked upon as a case of painless stone obstruction. At operation, however, no stone was discoverable. When the duodenum was opened carcinoma of the ampulla of Vater was found and removed by cautery, removing almost as much of the pancreas as was done in the case reported by Doctor Parsons. The tube was sewed into the common duct, but the patient was too sick to permit anything else to be done. A letter received from her a few weeks ago stated she was quite well.

In 1904, Doctor Muller reported a case discovered at autopsy and discussed the pathology of the pancreas. Notwithstanding the fact that no pancreas remained except a mass of fatty tissue in which the islets were completely preserved, dotted here and there in the fat, the patient had suffered no serious symptoms of indigestion. He felt that whereas possibly in the case reported by Doctor Parsons there was a good sized accessory duct, nevertheless it might be possible, also, that external secretion of the pancreas is unnecessary in the maintenance of reasonably good health.

DR. WALTER E. LEE (Philadelphia) stated in connection with reporting three cases from the Graduate Hospital of the University of Pennsylvania the literature on the subject of carcinoma of the ampulla of Vater was reviewed up until 1933, with only 36 completed reports and 17 references being found and accepted. The most impressive feature of the disease is the difficulty of making a preoperative diagnosis of it as the cause of common duct obstruction. Another important clinical feature in his three cases was the uncontrollable hemorrhage that appeared on the sixth and eighth postoperative days. Bleeding occurred then in practically all of the serous mucosa lined cavities. The marked preoperative jaundice was considerably relieved following the drainage of the common duct proximal to the obstruction, but the bleeding could not be stopped.

Although doubting that it would have been possible to have successfully included the procedure described by Doctor Parsons in any of the three cases operated upon, in view of preoperative conditions and doubt concerning the lesion, he felt that in the future this would be attempted. The fact that an individual can not only survive but live an apparently normal physiologic existence after ligation of the main pancreatic duct has made Doctor Parsons' procedure a logical one. Dividing it into two stages would seem to be absolutely necessary. These patients when they reach the surgeon are rarely in condition to stand a great deal of radical surgery and it might even be necessary in some instances to prolong it over three stages, (1) the cholecystogastrostomy, (2) the gastro-enterostomy, and (3) excision of the duodenum, involved ampulla and terminal portion of the common duct.

The procedure described by Doctor Muller, said Doctor Lee, would apply only to a small localized lesion of the ampulla. Doctor Parsons' contribution, he felt, had opened a new field and would offer hope for at least prolongation of life in a lesion hitherto generally considered inoperable.

DR. ALLEN O. WHIPPLE (New York) explained that one of the chief reasons it was deemed wise to carry out the operation described by Doctor Parsons in two stages was the deep jaundice of the patient. Patients stand even three procedures like cholecystogastrostomy, gastro-enterostomy and ligation of the common duct, he said, much better than if the duodenum is opened and the pancreas damaged for the reason that bleeding can be more adequately controlled. He learned a great deal from the first case in which he endeavored to carry out the procedure in one stage, attempting to implant the resected head of the pancreas into the duodenum. This he felt was a

very hazardous, useless operation because it involved doing the very worst thing that could be done to the pancreas, that is, to activate secretion coming out of the dissected area in the pancreas by duodenal secretion. The operations of Sauv  and Desjardins are done in one stage and are therefore very complicated, there being only one case in the literature in which the Desjardins technic has been applied which lived 11 months. In every experimental instance in Doctor Whipple's experience, there was digestion of the suture line if the pancreas was implanted into the duodenum.

As a result of his first case and of Doctor Parsons' case, the first stage operation was again done by Doctor Whipple three weeks ago in a patient still in the hospital. The patient went through the procedure exceedingly well, the jaundice has entirely cleared up and weight has increased. No attempt was made in the second stage to unite the duodenum. Instead, depending on the gastro-enterostomy of the first stage, the duodenum from close to the pylorus down to the area where the superior mesenteric vessels cross it, was removed with a wedge of pancreas. The specimen showed that all tumor tissue was separated by 2.5 cm. from the cut edge of the pancreas. The patient has continued to do very well. Although there has been a slight leakage of pancreatic juice, it has not been activated or irritating to the skin. When this operation is performed in these patients, there is already obstruction of the pancreatic duct, the pancreas has begun to atrophy, and pancreatic juice is not being excreted. Hence ligation of the pancreatic duct does not immediately throw them into pancreatic insufficiency.

INTRA-ABDOMINAL APOPLEXY

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FROM THE SURGICAL CLINIC OF THE PETER BENT BRIGHAM HOSPITAL, BOSTON, MASSACHUSETTS

INTRA-ABDOMINAL apoplexy is the spontaneous rupture of an arteriosclerotic artery of one of the abdominal viscera. In this region it is the counterpart of cerebral hemorrhage, but whereas the latter condition is common, intra-abdominal apoplexy is either extremely rare or seldom recognized. In 1931, Green and Powers¹ reported such a case treated at the Peter Bent Brigham Hospital and summarized the records of five other patients which had been recorded prior to that time. Since 1931, two more reports of intra-abdominal apoplexy have appeared.² This communication is to record the second case of intra-abdominal apoplexy that has been seen at the Peter Bent Brigham Hospital. As far as can be determined, it is the eighth to be noted in the literature.

CASE REPORT

P. B. B. H., Surg. No. 46984. Mrs. C. R., a white woman, 62 years of age, entered the hospital July 26, 1934, because of abdominal pain and vomiting.

Present Illness.—Eighteen hours before admission the patient was awakened with severe pain in the left precordial and left upper abdominal regions. Shortly after the onset of the pain, which was constant and nonradiating, she was seen by her family physician, who found her in a state of collapse, with a systolic blood pressure of 130 Mm. of Hg., a rapid pulse and a cold moist skin. A preliminary diagnosis of coronary occlusion was made and morphine was administered. The pain gradually extended over the entire abdomen and soon was associated with nausea and attempts to vomit. Her bowels

did not move but she did pass flatus. A cardiologist was consulted and he referred the patient to the surgical service of the Peter Bent Brigham Hospital, because he found marked abdominal tenderness and spasm. His impression was that the patient was suffering from an acute abdominal condition. Morphine was again administered two hours before she was sent to the hospital.

Past History.—The patient was known to have had hypertension. She had suffered from bilateral cataract and glaucoma for seven years. Six years prior to admission a cerebral vascular accident had occurred, with a resulting hemiplegia that disappeared after two years. Six months before admission she had had an attack of abdominal pain lasting several hours, after which she vomited blood. During the two weeks prior to admission the patient had been suffering from increased fatigability, dyspnea, and gripping sensations in the precordium. Her blood pressure during this time averaged 170/100. Her general condition just prior to the present illness had improved after rest and digitalis therapy.

Physical Examination.—The patient was an euphoric, slightly disoriented, and almost totally blind elderly woman. The lungs were slightly emphysematous with dulness and numerous râles at the right base. The heart was slightly enlarged, the sounds were faint, and a systolic murmur was heard at the apex, the pulse was regular and of fair quality with a rate of 90, the blood pressure was 120/70. Abdominal distension was present but tympani was not marked; in fact, there was shifting dulness in the flanks. The entire abdomen was markedly tender, more so in the left upper quadrant than elsewhere. Some involuntary spasm was present but this was not striking. Pelvic and rectal examinations revealed vague general tenderness but otherwise contributed no further localizing signs. The extremities showed markedly tortuous and hardened arteries. There was no edema.

Laboratory Studies.—The blood showed 4,000,000 erythrocytes; the leukocyte count was 18,700, with a differential of 93 per cent polymorphonuclear cells. Examination of the urine was negative except for the presence of hyaline casts. Blood Wassermann and Hinton tests reported later proved to be negative. Roentgenograms with fluoroscopy of the chest and abdomen demonstrated a moderate amount of fluid in both abdominal and pleural cavities, but the heart was not markedly enlarged. Electrocardiograms, including a fourth lead, were not suggestive of coronary occlusion.

Preoperative Course.—The patient was observed because of a suspicion of a non-operable cardiovascular condition, but after waiting for two hours, spasm and tenderness of the abdomen had increased, and laparotomy was advised. The preoperative diagnosis was mesenteric vascular occlusion.

Operation.—July 27, 1934. Abdominal exploration with evacuation of hemoperitoneum. Ether anesthesia. A right paramedian incision disclosed a large amount of liquid blood free in the peritoneal cavity. Sheets of clotted blood were found in the left upper abdomen extending down over the omentum from the region of the stomach. The gastrohepatic omentum was a greatly thickened, hemorrhagic mass. No free bleeding was seen, but the source of hemorrhage obviously had been an artery in the gastrohepatic omentum. There was no evidence of acute pancreatitis, perforated ulcer or malignancy. Most of the clots and liquid blood were evacuated from the abdomen, and after the fact was established that no fresh bleeding was taking place, the wound was closed without drainage. The patient stood the procedure fairly well, although the blood pressure dropped to 70/50 and the pulse rose to 130 during the exploration.

Postoperative Course.—Recovery from the operation was prompt, and the convalescence was uneventful except for a recurrence, during the second week, of mild abdominal pain associated with tenderness, chiefly in the right lower quadrant, accompanied by a slightly lowered blood pressure which lasted for several days. The possibility of a recurrence of hemorrhage was considered, but the symptoms soon ceased and convalescence again became very satisfactory. The patient was quite well six months after operation, and she has had no recurrence of abdominal symptoms.

COMMENT

This case conforms exactly to the condition described as abdominal apoplexy by Green and Powers. The appearances of the gastrohepatic ligation of the two cases that have been seen in this surgical service are almost identical. In the instance herein described hemorrhage was more extensive but had ceased before laparotomy was performed.

Although the condition of intra-abdominal apoplexy appears to be surgical, and ligation of the ruptured vessel is to be desired, the successful course of this particular patient demonstrates, as in hemorrhage from duodenal ulcer, that actual ligation of the vessel may not be necessary, if the bleeding can be controlled by conservative medical measures. A larger incision and a very careful search of the entire gastrohepatic omentum, as would have been necessary in order to find the ruptured vessel in this instance, might have prolonged the operation sufficiently to have caused a fatality.

SUMMARY

A second case of intra-abdominal apoplexy is reported. Diagnosis was made by abdominal exploration. The patient recovered. This appears to be the eighth such case to be reported in medical literature.

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RETROPERITONEAL CHYLE CYST

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CHYLE cysts are unusually rare, those of the mesentery have been found occasionally but a search of the literature does not reveal a single instance of retroperitoneal chyle cyst in the region of the cysterna chyli.

CASE REPORT

A female, 38 years old, March 4, 1934, suffered a severe attack of pain along the right side of her spine in the region of the first and second lumbar vertebrae, which radiated anteriorly to the upper right quadrant. She did not vomit but felt very nauseated and complained of headache. She had noted a marked loss of weight in spite of a very good appetite and forced feedings. Present weight 113 pounds, two years previously 140 pounds. Constipation marked, necessitating mineral oil daily. She also felt extremely weak and fatigued at the end of her day's work. At times she had a feeling of pain in the upper abdomen, not associated with food. Belching and distension after meals was not pronounced. Her past history was essentially negative. She had never been acutely ill before.

Examination showed a rather thin individual who appeared acutely ill. Head and neck negative. Eyes reacted to light accommodation. Heart and lungs appeared normal. Examination of the abdomen revealed a marked rigidity in the right upper quadrant. Pressure over the gallbladder region elicited extreme pain anteriorly which radiated posteriorly. Pulse 80. Temperature 98°. Blood pressure 115/80. The symptoms and physical findings suggested a possible gallbladder colic and she was advised to rest in

FIG. 1.—Showing the relative situation of the cyst retroperitoneally and the adjacent viscera.

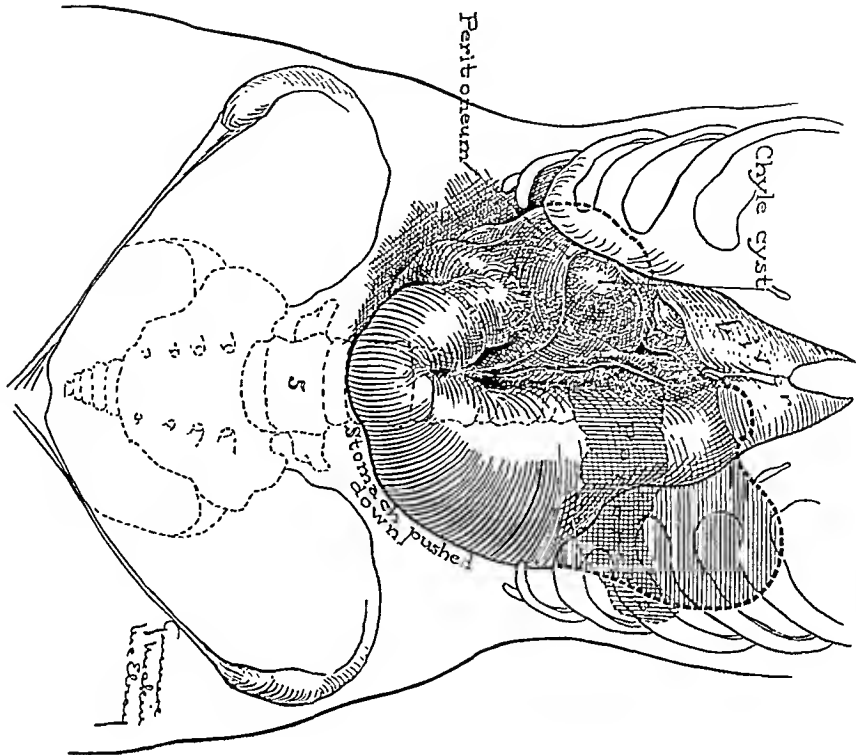
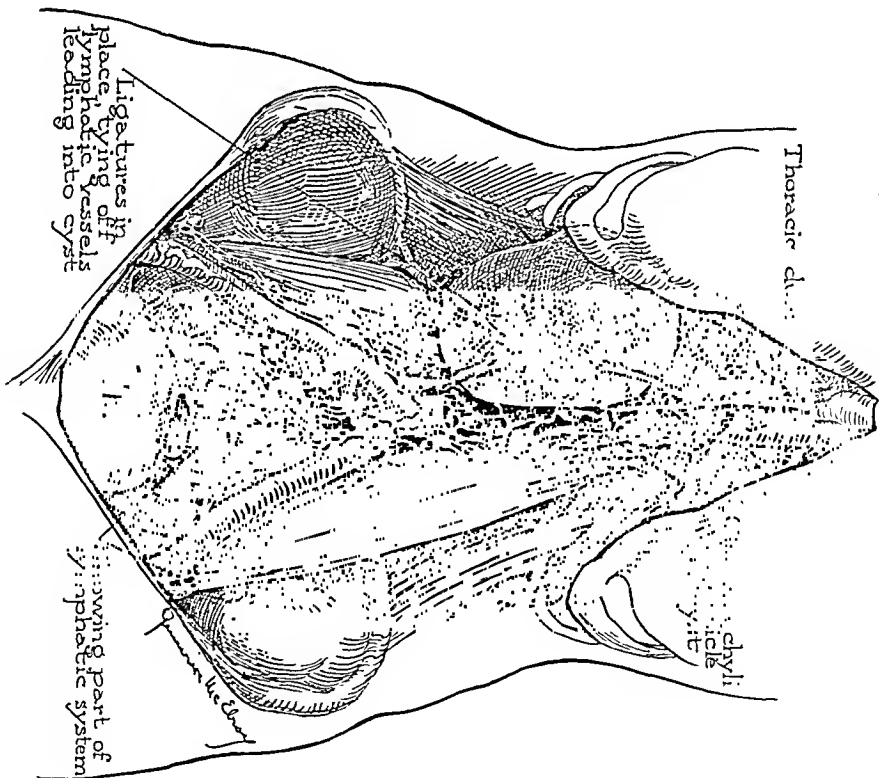


FIG. 2.—Showing the three large vessels entering the cyst.



bed with an ice bag applied to the abdomen. The next day her acute pain had entirely disappeared, but there still remained a dull ache in the right upper quadrant. Palpation demonstrated a distended hard mass in the upper right quadrant about the size of an orange, which was very tender to pressure and which moved slightly with respiration. The urine did not contain bile and the sclera was clear. A diagnosis of a stone blocking the cystic duct with a hydrops of the gallbladder was made.

Four days later all pain had disappeared and the distended mass had become somewhat less tense. She entered the Michael Reese Hospital March 9, 1934. The red, white and hemoglobin count were normal. The Wassermann test was negative, coagulation time seven minutes. Calcium chloride was given intravenously and on the morning of operation 15 units of parathormone was administered hypodermically. The coagulation time decreased to four minutes.

Operation.—Upon opening the abdomen, a mass presented about the size of a grapefruit impinging on the anterior abdominal wall. The tumor was retroperitoneal and seemed to extend backward to the vertebral column. The gallbladder and liver formed its upper right border; the stomach and duodenum its left and inferior border (Fig. 1).

The peritoneum and tissues overlying the cyst were incised, which loosened the mass down to its base which appeared to be attached to the tissues overlying and to the right of the vertebral column. Anteriorly, there were three large vessels leading into the cyst which seemed to be dilated lymphatics (Fig. 2). The size of the cyst was reduced by aspiration and was found to contain a milky white fluid resembling chyle. This was verified on microscopic examination. The lymphatic vessels leading into the cyst were doubly ligated and divided. The base of the cyst was freed and removed. The lymphatic vessels that were cut seemed to lead upward and downward to the right of the aorta and apparently drained into the cisterna chyli. A drain was inserted to the base of the cavity. The patient made an uneventful recovery, and was discharged on the tenth day. There was never any drainage. Six months after the operation the patient had gained 15 pounds and she appeared in perfect health.

CONCLUSIONS

A search of the literature reveals no report of a retroperitoneal chyle cyst of this nature. This case is not to be confused with mesenteric chyle cysts of which there are some 96 on record.

The following phenomena are of interest.

- (1) Her severe pain in the back to the right of the spine.
- (2) Severe pain on pressure anteriorly and posteriorly.
- (3) Normal pulse and temperature throughout the attack.
- (4) Her marked loss in weight from 140 to 113 pounds with fatigue and general weakness.
- (5) Its relatively simple extirpation.

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